ENVIRONMENTAL PROTECTION

Vegreville Flood Risk Mapping Study

Canada-Alberta Flood Damage Reduction Program

April 1994

SNC · LAVALIN
Edmonton

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April 18, 1994

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Attention: Mr. Terry Winhold, P. Eng.
Project Manager

Dear Mr. Winhold:

Reference: Vegreville Flood Risk Mapping Study - Final Report

We are pleased to submit herewith fifty (50) copies of the Final Report for the Vegreville Flood Risk Mapping Study encompassing both the Vermilion River and the North Drain West Tributary (NDWT) channel through the study area.

The project study file is being transmitted under separate cover.

We appreciate having been of service and would welcome future opportunities to be involved in the Canada-Alberta Flood Damage Reduction Program.

Yours truly,

SNC•LAVALIN INC.

Neil van der Gugten

Neil van der Gugten, M.A.Sc., P. Eng.
Project Manager

NvdG/ch
encl.

cc: File 6005-CC2

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VEGREVILLE FLOOD RISK

MAPPING STUDY

Submitted to:

ALBERTA ENVIRONMENTAL PROTECTION
RIVER ENGINEERING BRANCH

For

CANADA-ALBERTA
FLOOD DAMAGE REDUCTION PROGRAM

Submitted by:

SNC•LAVALIN INC.

April 1994

Ref: 6005/mappstud.nvg

Executive Summary

The Vegreville Flood Risk Mapping Study has been carried out as part of the Canada - Alberta Flood Damage Reduction Program. The study analyzed available hydrology, channel geometry and crossing data to prepare flood risk maps for a 14 kilometre reach of the Vermilion River and a 13 kilometre reach of a tributary channel through the Town of Vegreville and adjacent portions of the County of Minburn No. 27.

The highest flood of record occurred in April 1974 and is estimated to have a return period of about 100 years. All other floods within the 32 year period of record have return periods of less than 20 years. Ice-jams are not a significant cause of flooding.

Water surface profiles for open-water conditions were calculated using the U.S. Corps of Engineers HEC-2 computer model. The model was calibrated for the Vermilion River using 1974 and 1983 observed high water levels. The model for the tributary channel was calibrated using water levels inferred from the 1974 flood aerial photography and the orthophoto contour maps.

Flood risk areas were defined and divided into floodway and flood fringe zones in accordance with the Alberta Environment 1990 Guidelines for Floodplain Delineation. These zones are shown on Flood Risk Maps - 1:5000 scale orthophoto mosaic maps with 1 metre contour interval topographic overlay.

The flood risk maps show that the 100-year flood would cause significant flooding of agricultural land in a large meander loop complex on the Vermilion River just upstream of Highway 16, of the Kinsmen Park area just downstream of Highway 16, and of the Vegreville airport area and adjacent golf course and agricultural land. The residential areas of Vegreville and the hospital adjacent to Kinsmen Park would not be inundated.

The North Drain West Tributary channel contributes significantly to flooding in the airport area due to many small and blocked culverts in the adjacent golf course area. This flooding could be reduced by reconstruction of the culvert crossings to provide a lower overflow level.

There are several structures within the floodway zone along the Vermilion River: a house and garage on the left bank just south of Old Airport Road and several outbuildings on the right bank of the meander loop complex south of Highway 16. Along the North Drain West Tributary, only a stormwater pond and pumphouse, located between Highway 16 and 75 Street, are within the floodway.

Acknowledgements

The Vegreville Flood Risk Mapping Study was managed by Mr. Terry Winhold of the River Engineering Branch of Alberta Environmental Protection. Mr. Winhold set the project criteria, supplied cross-section and hydrologic data and provided overall direction, assisted by Mr. Terry Ingraham, Mr. Andy de Boer and Mr. Bryce Haimila.

The study was conducted by Mr. Neil van der Gugten of SNC-LAVALIN, Inc, supported by Mr. Tim Cartmell, Mr. Lorne Cornfield, and Ms. Isabelle Ong.

Assistance and information was provided by the following individuals and agencies:

- Frank Slobosz — Water Survey of Canada, Calgary
- Mike Dowhun — Town of Vegreville
- Orville Tebbutt — Town of Vegreville
- Bridge Engineering Branch — Alberta Transportation and Utilities
- Bridges and Structures — Canadian National Railways

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1.0 INTRODUCTION

1.1 Flood Damage Reduction Program

The Canada-Alberta Flood Damage Reduction Program was initiated based on "An Agreement Respecting Flood Damage Reduction and Flood Risk Mapping in Alberta" signed by the Federal government of Canada and the Provincial government of Alberta in April, 1989. This program applies a non-structural method of flood damage reduction by identifying urban areas subject to flood damages and by encouraging solutions such as land use planning, zoning, flood proofing, and flood preparedness.

The Flood Damage Reduction program includes the following components as defined by Alberta Environment (1990):

- Identify, map, and designate flood risk areas in urban communities across the province.
- Increase awareness of flood risk among the general public, industry, and government agencies through a public information program.
- Regulate new development in flood risk areas using new federal and provincial government policies.
- Encourage municipalities to develop zoning by-laws recognizing the designated flood risk areas.

As part of the Canada-Alberta Flood Damage Reduction Program, the River Engineering Branch of Alberta Environmental Protection commissioned SNC-LAVALIN INC. to undertake this Vegreville Flood Risk Mapping Study.

1.2 Study Objectives

The purpose of this study is to prepare flood risk maps for a 14 kilometre long reach of the Vermilion River and a 13 kilometre long reach of an adjacent channel (the North Drain - West Tributary Channel) through the Town of Vegreville and adjacent portions of the County of Minburn No. 27.

The specific objectives of this study are to:

- conduct a review of the history of flooding in the Town of Vegreville;
- conduct hydraulic analysis and calculate open-water flood levels for various return period floods;
- delineate the flood risk boundaries and floodway limits for the 100 year flood event; and

- prepare flood frequency maps showing the flood risk boundaries for current conditions through the Town of Vegreville and adjacent areas for the 10, 50 and 100 year flood events.

The designation of flood risk and floodway zones provides the basis for future floodplain management and development for Town planners, Provincial government agencies, and the public.

This study does not examine the potential for groundwater flooding.

1.3 Study Area

The Town of Vegreville is located approximately 100 km east of Edmonton on Highway 16 (Figure 1.1). The Vermilion River flows northerly through the eastern edges of the town. The North Drain - West Tributary Channel (NDWT) enters the study area from the west, passing through the northern undeveloped fringe of the town and then turning north to flow parallel to the Vermilion River. The NDWT joins the Vermilion River some distance downstream of the study area.

The study area extends from the southwest corner of 23-52-15 W4M, at the western limit of the town boundary, following the NDWT eastward, and from the Highway 16 by-pass, following the Vermilion River northerly, to the north section line of Section 30, Township 52, Range 14 (west of the 4th Meridian).

The reach of the Vermilion River included in the study is 14.3 km long and located as shown in Figure 1.1. It includes 9 bridges and 1 culvert crossing. The NDWT reach in the study is 12.9 km long and has a 0.6 km long tributary identified as Swale "A". The NDWT study reach has 21 crossings. One is a weir, two are bridges, and the rest are culverts.

2.0 HISTORY OF FLOODING

2.1 General

The discharge of the Vermilion River through the study area has been monitored since 1962. The largest flood in the period of record occurred in April 1974 and corresponds closely to the estimated 100-year flood magnitude.

Measurements of flood flows or levels for events prior to 1962 do not appear to exist. A 1983 study of flooding in the Vegreville area (Ref. 1) reports that "minor" floods occurred in 1940, 1943 and 1948 while in 1956 a flood large enough to cause significant municipal damage was experienced.

The annual flood peak generally occurs in March or April and is caused by spring snow melt. However, in about 1 out of every 5 years, on average, the annual peak occurs in summer or early fall as a result of rain.

Spring snow melt floods are typically associated with ice breakup, and some piling up and accumulation of ice as well as debris is reported to be a factor in flood events (Ref. 2). However, ice-jamming as a principal cause of flooding does not appear to be a factor.

There is reported to be significant beaver activity in both the Vermilion River and the NDWT channel (Ref. 3), resulting in variable degrees of channel restriction by beaver dams.

2.2 Recent Floods

The largest recorded flood occurred in April 1974. The instantaneous peak of 77.3 m^3/sec. and the daily peak of 74.5 m^3/sec. occurred on April 20, 1974. This flood caused considerable damage and was thought by local residents to have been the worst flood in 40 to 50 years.

The 1983 study reports the extent of flooding as follows:

> "The primary concern at the time of the flood was the disruption of hospital services, which resulted when floodwaters cut off access to the hospital along 43 Street and backed up sanitary sewers, forcing the evacuation of patients. In addition, considerable flooding and property damage occurred in residential areas in the northeast section of the town. The area between the river channel and 43 Street was directly affected by overbank flooding, whereas water entered other low lying areas on either side of 54A Avenue by flowing north along 43 Street and west along 54A Avenue.
>
> The Kinsmen Park, opposite the hospital, was also inundated during the 1974 flood and widespread flooding occurred outside of Vegreville, primarily on agricultural land bordering the river channel.

Aerial photography of the 1974 flood was flown on April 22, two days after the peak, when the discharge was 63.5m^3/sec. and flood levels were about 0.25m lower than at the peak.

3.0 AVAILABLE DATA

3.1 Hydrology Report

A hydrologic study was carried out by the Technical Services Division of Alberta Environment in 1991 (Ref. 4), to develop estimates of flood frequencies for the Vermilion River and the NDWT channel.

3.1.1 Vermilion River

The 1962-1991 period of record used in the study includes 29 annual peak daily and 20 annual peak instantaneous discharges of which 14 years have both types of annual peaks. Annual instantaneous peaks for the 9 missing years were estimated by correlation of instantaneous and daily peak values for the 14 common years of data. Attempts to further extend the data set by regional correlation failed. The completed annual flood series is given in Table 3.1.

Frequency analysis was carried out on the annual instantaneous peaks given in Table 3.1. Various frequency distributions were tested and the Log-Pearson Type III distribution was found to provide the best fit to the data. The resulting flood frequency estimates are given in Table 3.2.

VEGREVILLE FLOOD RISK MAPPING STUDY

TABLE 3.1

VERMILION RIVER AT VEGREVILLE - ANNUAL FLOODS

Year	Annual Maximum Daily Discharge (m^3/s)		Date	Annual Maximum Instantaneous Discharge (m^3/s)		Date	
1962	4.09	e	N/A	4.53		N/A	
1963	31.3	e	N/A	32.6		N/A	
1964	7.38	e	N/A	7.93		N/A	
1965	38.0	e	N/A	39.6		N/A	
1966	4.64	e	N/A	5.10		N/A	
1967	10.4	e	N/A	11.0		N/A	
1968	6.31		Mar. 7	6.85	e	Mar. 7	e
1969	13.3		Apr. 12	14.1	e	Apr. 12	e
1970	6.48		Apr. 13	7.02	e	Apr. 13	e
1971	20.7		Apr. 18	21.6		Apr. 18	
1972	12.2		Apr. 15	12.5		Apr. 15	
1973	18.5		Jul. 7	18.8		Jul. 7	
1974	74.5		Apr. 20	77.3		Apr. 20	
1975	9.57		Apr. 25	10.4		Apr. 25	
1976	2.14		Apr. 12	2.55	e	Apr. 12	e
1977	N/A		N/A	N/A		N/A	
1978	5.01		Sept. 21	5.10		Sept. 21	
1979	24.3		Apr. 20	25.3		Apr. 20	
1980	6.26		Apr. 14	6.42		Apr. 14	
1981	6.77		Mar. 19	7.32	e	Mar. 19	e
1982	15.8		Jul. 8	16.2		Jul. 8	
1983	22.3		Jul. 2	22.6		Jul. 2	
1984	3.91		Mar. 31	4.37	e	Mar. 31	e
1985	11.1		Apr. 4	11.9		Apr. 4	
1986	21.6		Mar. 31	22.3		Mar. 31	
1987	14.2		Apr. 10	17.8		Apr. 10	
1988	0.686		Aug. 21	1.28		Aug. 20	
1989	1.80		Apr. 8	2.20	e	Apr. 8	e
1990	13.6		Apr. 2	14.4	e	Apr. 2	e
1991	0.846		Apr. 8	1.22	e	Apr. 8	e

e - estimated

N/A - not available

Station Data

1962 - 1967:	Alberta Environment (annual maximum gauge height)
1968 - 1986:	Water Survey of Canada Stn. 05EE003 (1590 km^2)
1987 - 1991:	Water Survey of Canada Stn. 05EE009 (1630 km^2)

TABLE 3.2

VERMILION RIVER AT VEGREVILLE - FLOOD FREQUENCIES

Return Period (yrs)	Annual Maximum Instantaneous Discharge (m^3/sec.)
100	73
50	60
20	43
10	32
5	22
2	10

The 100-year flood peak of 73m^3/sec. is within 5% of the 1974 flood of record when discharge peaked at 77.3m^3/sec. Since the accuracy of flood peak measurement is no better than $\pm$ 5%, the 1974 flood can be considered to have been a 100-year flood event.

3.1.2 North Drain - West Tributary Channel

Alberta Environment collected three years (1980-1982) of flow data on the North Drain - West Tributary (NDWT) at Station 05EE923 located at the Highway 16 crossing. The annual peak instantaneous flows, together with the Vermilion River peaks for the same period, are listed in Table 3.3.

TABLE 3.3

NDWT AND VERMILION RIVER

ANNUAL INSTANTANEOUS PEAK FLOW DATA

Year	NDWT			Vermilion River		
	Peak Flow m^3/sec.	Unit Peak Flow m^3/sec/km^2	Date	Peak Flow m^3/sec.	Unit Peak Flow m^3/sec/km^2	Date
1980	0.309	0.0025	Apr. 9	6.42	0.0040	Apr. 14
1981	0.586	0.0047	Apr. 18	7.32	0.0046	Mar. 19
1982	0.265	0.0021	Apr. 21	16.2	0.0102	Jul. 8

In the Alberta Environment hydrologic study, it was decided that these data were not adequate to form a basis for estimation, and that, on the basis of similar watershed characteristics, the NDWT flood frequency should be estimated using a linear area transfer relationship. However, the resulting values, shown in Table 3.4, yielded unreasonably high water levels when used in the HEC-2 model. More reasonable lower values were estimated by using the HEC-2 model as a calibration mechanism to approximate the observed extent of flooding for the 1974 flood, which was considered equal to the 100-year flood event (See Section 5.4.2). The higher frequency flood events were adjusted by the same ratio; the calibrated values are shown in Table 3.4

TABLE 3.4

NDWT AT VEGREVILLE - (BELOW SWALE "A")

FLOOD FREQUENCIES

Return Period (yrs)	Annual Maximum Instantaneous Discharge (m^3/sec.)	
	Hydrology Report	Calibrated Values
100	5.74	3.30
50	4.72	2.71
20	3.38	1.94
10	2.52	1.45
5	1.73	0.99
2	0.79	0.45

The Hydrology Report recommended that coincidence of flood peaks on the Vermilion River and the NDWT should be assumed for flood risk mapping studies.

3.2 Surveys and Mapping

3.2.1 Surveys

Cross sections for this study were obtained using two types of surveys. Channel cross sections for both the Vermilion River and the NDWT were obtained by field survey carried out by Alberta Environmental Protection, Survey Branch (Edmonton Region). The overbank portions of the cross sections were obtained by photogrammetric survey carried out by Western Photogrammetry Ltd., Edmonton.

Vertical Datum is Geodetic. Horizontal Datum is 30MTM, NAD27.

3.2.2 Mapping

Three orthophoto map sheets covering the study area were produced by Western Photogrammetry Ltd. under contract to Alberta Environmental Protection, using May, 1991 aerial photography. The map sheets are at a scale of 1:5000 and were provided with 1 m contours covering the channel and floodplain portions of the study area. Vertical and horizontal control surveys for photogrammetric control were carried out to third level order control standards.

3.3 Highwater Marks

Two sets of highwater marks are available for the Vermilion River: one for the 1974 flood and one for a summer flood in 1983. The data are listed in Table 3.5.

TABLE 3.5

VERMILION RIVER AT VEGREVILLE
RECORDED HIGH WATER SURFACE ELEVATIONS

Date	Discharge (m^3/sec.)	Location	Water Surface El. (m.GSC)
74-4-20	77.3	Highway 16 Bridge	634.91
74-4-20	77.3	43 Street Bridge	634.14
83-6-28	21.0	Highway 16 Bridge (D/S)	632.85
83-6-28	21.0	CNR Bridge (D/S)	632.50
83-6-28	21.0	43 Street Bridge (D/S)	630.87
83-6-28	21.0	61 Avenue Bridge (D/S)	630.37
83-6-28	21.0	Old Airport Road Bridge (D/S)	630.02

The 1983 water surface elevations were taken at the downstream (D/S) side of the bridges due to the presence of significant amounts of debris lodged on the upstream side of three of the five bridges. Photographs of conditions at each of the bridges are attached as Figures 3.1 to 3.5.

3.4 Rating Curves

The rating curve for the Vermilion River at the Water Survey of Canada Station 05EE009, located approximately 250 m downstream of the Highway 16 Bridge, is not tied to Geodetic Datum and is not defined above a discharge of 15 m^3/sec. It is therefore of limited value.

The 1983 study (Ref. 1) provided two rating curves for the Vermilion River at the Highway 16 bridge (Figure 3.6). One curve is based on observations made during the 1974 flood event. A second curve is based on use of the HEC-2 model, calibrated on the basis of the 1974 flood observations, and applied to an improved river channel. The present study, using the same calibration data supplemented by the 1983 highwater marks, has produced a third curve applicable to the current river channel geometry.

3.5 Flood Photography

Aerial photographs were taken of the 1974 flood. The photos were taken on April 22, two days after the peak, when the flow was 63.5 m^3/sec. and water levels were about 0.25 m lower than peak levels. A photo mosaic of the 1974 flood photos over the study area is shown in Figure 3.7.

Ground photos of conditions at Vermilion River bridge crossings for the 1983 summer flood are shown in Figures 3.1 to 3.5. The photos were taken on June 28 at a flow of 21.0 m^3/sec. The peak daily flow of 22.3 m^3/sec. occurred on July 2.

4.0 RIVER AND VALLEY FEATURES

4.1 General Description

The Vermilion River at Vegreville drains a 1,630 km² area of the east central Alberta plains. The drainage basin is gently sloping to undulating, largely cultivated, and poorly drained, especially in the upper portions where there are numerous marsh and wetland areas.

The channel of the Vermilion River is cut some 4 to 5 metres into the plain, with a limited flood plain developed by the progression of river meanders; there is no river valley. The channel is very contorted, having an irregular meander pattern. There are many oxbows in various stages of infilling, created by both natural and man-made cut-offs.

Downstream of 61 Avenue, the floodplain widens somewhat into a larger flat area which may have been a shallow wetland at some earlier time. An airport has been developed in this flat area.

The North Drain West Tributary channel consists of two distinct channel reaches. The upper reach is a natural drainage course without meanders. The lower reach, starting just downstream of 47 Street, in the low floodplain area around the airport, is a former channel of the Vermilion River, and exhibits the same highly contorted and irregular meander pattern.

4.2 Channel Characteristics

4.2.1 Vermilion River

The Vermilion River channel has an irregular but pronounced meander pattern, which, combined with the flat slope of the land, results in a very flat channel slope and low flow velocities. The average bed slope through the study area is 0.0004. The upper reach above the CNR crossing has a bed slope of 0.0003, the middle reach from the CNR to 61 Avenue (through which the channel has been shortened through cut-offs) has a slope of 0.0010, and the lower reach through the airport area has a slope of 0.0003.

Average channel flow velocities for the mean annual flood range from 0.2 to 0.8 m/sec. For the 100-year flood, average channel velocities can reach as high as 1.2m/sec., but generally only at bridge crossings and at the narrowest channel sections. The bed is generally paved with coarse gravel or cobbles.

The Vermilion River has cut its channel through 4 to 5 metres of silty clay till to a more resistant underlying weathered shale. The river banks are thus susceptible to erosion and active meandering is occurring. Erosion is concentrated at the sharper bends, and natural cutoffs of meander loops have resulted in oxbow lakes. A floodplain, developed by the progression of meandering, lies 1 to 2 metres lower than the surrounding plains, at a level roughly corresponding to the 5 to 10 year flood level. Average flow velocities in the flooded overbank do not exceed 0.5m/sec. even for the 100-year flood.

The flat slope and low flow velocities make the channel attractive to beaver, who build dams across the channel and in addition generate significant amounts of debris. Both Town of Vegreville staff and Water Survey of Canada staff report beaver dam construction on the Vermilion River (Refs. 2, 3).

4.2.2 North Drain - West Tributary

The upper reach of the NDWT is not much more than a shallow swale without clearly defined banks, up to about one metre deep below the surrounding land. The channel in this reach runs from west to east with gentle to moderate curvature, without meanders. The channel appears to flow only seasonally due to snowmelt, and in response to major rainstorms. The channel is largely vegetated and portions may be cultivated during the growing season.

The upper reach upstream of 75 Street, between cross-sections 74 and 89, has a secondary channel looping to the north. Subsequent analysis indicated that this secondary channel does not convey flow for the magnitudes of discharge considered in this study.

Commencing just downstream of the 47 Street crossing, the NDWT drainage channel flows into a former channel of the Vermilion River. This lower reach of the NDWT therefore has the same highly contorted and meandering geometric characteristics as the Vermilion River. A golf course has been developed in the lower reach area, west of the airport.

The bed slope along the upper reach of the NDWT averages 0.0013. The bed slope along the lower reach is 0.0003, the same as for the Vermilion River through this area.

Flow velocities through the upper reach can average up to 1.0 to 1.5m/sec., although backwater effects caused by fords and undersized culverts generally limit velocities to considerably less throughout most of the reach. Channel flow velocities in the lower reach (consisting of the Vermilion River paleochannel) range from 0.02m/sec. for the 2-year flood to 0.30 m/sec. for the 100-year flood. Velocities in the lower reach are low as the channel is oversized relative to the flow magnitudes. Significant overbank flows are caused by blocked culverts throughout the golf course area.

4.3 Floodplain Characteristics

The channel of the Vermilion River is cut some 4 to 5 metres below the surrounding plains landscape. A relatively small and poorly defined floodplain can generally be found adjacent to one or both sides of the channel, at a level 1 to 2 metres below the surrounding land, corresponding to the 5 to 10 year flood level. This floodplain was formed by the historical movement of the channel through meander progression, cutoff of meander loops, and infilling of oxbows. A broad shallow floodplain exists beyond the channel banks in the lower reach within the study area.

The Vermilion River floodplain is predominantly cultivated land, with some vegetated areas left as strips along the banks. Through the settled area of Vegreville, the floodplain has been developed as a park (Kinsmen Park), as residential land and a cemetery. An airport is located on the floodplain between the present Vermilion River channel and the previous channel now captured by the NDWT.

The upper reach of the NDWT, being a drainage swale with seasonal flow, does not have a floodplain. The lower reach of the NDWT flows through the floodplain of the Vermilion River. A golf course and shooting range have been developed along this reach, west of the airport.

4.4 Man-Made Features

4.4.1 Vermilion River

There are ten crossings located within the 14.3 km study reach of the Vermilion River. Table 4.1 below identifies the type and location of each crossing. Locations are given in terms of chainage upstream from the downstream end of the study reach (cross-section 1), the cross-section number, and the name of the crossing.

TABLE 4.1

VERMILION RIVER STUDY REACH CROSSINGS

Station (km + m)	Cross-section No.	Name	Description
3 + 136	8	Old Airport Road	bridge
4 + 266	15	61 Avenue	bridge
4 + 813	20	Farm Access	8 culverts, plugged and buried; crossing functions as a ford
6 + 339	30	43 Street	bridge and utility pipe crossing
6 + 919	37	Park Access	footbridge
7 + 068	40	Park Access	footbridge
7 + 429	44	CNR	bridge (trestle)
7 + 951	50	Highway 16	bridge
10 + 710	69	Agriculture Canada Access	bridge
13 + 114	62	47 Street	bridge

Town of Vegreville Reach

In 1977, after the 1974 flood, channel improvements were carried out involving the construction of five meander loop cut-offs in the reach between 61 Avenue and Kinsmen Park. This work shortened the channel length by about 3000 meters, steepened the slope, increase flow velocities and reduced flood levels by an amount ranging from 1.0 m at the 43 Street Bridge to 0.3 m at the Highway 16 Bridge (see Fig. 3.6).

The increased velocities have accelerated erosion at the outsides of bends through this reach. As a result, riprap erosion protection has been placed on the outside bend portions of the remaining five main meander loops between 43 Street and Highway 16.

Channel maintenance, consisting of brush clearing and debris removal, occurs every few years on an as-needed basis.

County of Minburn Reaches

Some meander loop cutoffs have been constructed, such as at the new Highway 16 Bypass crossing at the upstream end of the study reach. In general however, these reaches are dominated by gradual natural processes including bend and channel erosion and deposition leading to meander progression and the development of natural cutoffs and oxbows.

Beaver activity results in beaver dam construction, causing ponding and backwater effects. Farmers are reluctant to have such beaver dams removed, as the ponded water is useful to them for supplemental irrigation or stock watering. It is for this reason that the Water Survey of Canada relocated their hydrometric station from 05EE003 to 05EE009 (Figure 1.1).

4.4.2 North Drain West Tributary

The NDWT channel has 21 crossings in the 12.9 km long study reach, as listed in Table 4.2 below.

TABLE 4.2

NORTH DRAIN WEST TRIBUTARY STUDY REACH CROSSINGS

Station (km + m)	Cross-Section No.	Name	Description
0 + 000	97	Right Bank Overflow	*1-800 + 1-450ϕ culverts
3 + 651	8	Golf Course Access	*1 - culvert with screen
3 + 719	10	Golf Course Access	*1 - 800 ϕ culvert with screen

Station (km + m)	Cross-Section No.	Name	Description
4 + 381	13	Golf Course Access	*1 - 600 ϕ culvert with screen
4 + 489	15	Golf Course Access	footbridge
4 + 821	17	Golf Course Access	*2 - 400 ϕ culverts with gates
5 + 188	19	Golf Course Access	*1 - 800 ϕ culvert with screen
5 + 275	96	Golf Course Access	1 - 1750 x 1000 arch culvert
5 + 342	23	Golf Course Access	*1 - 800 ϕ culvert with screen
5 + 814	25	Golf Course Access	*1 - 800 ϕ culvert
5 + 924	27	Golf Course Access	*1 - 750 ϕ culvert with screen
6 + 362	31	Old Airport Road	bridge; beaver dam in opening and fence crossing upstream
7 + 334	38	47 Street	1 - 1580 ϕ culvert
7 + 855	43	50 Street	1 - 1150 ϕ culvert
9 + 012	50	60 Street	1 - 1200 ϕ culvert
10 + 202	63	Access Road	2 - 600 ϕ culverts
10 + 225	65	CNR	1 - 1500 x 1725 box culvert
10 + 516	69	Highway 16	2 - 1200 ϕ culverts
10 + 890	74	75 Street	1 - 1500 x 1150 arch culvert
11 + 121	78	Access Road	2-500 ϕ culverts
11 + 540	82	Access Road	rock weir

* Culverts which are blocked or are expected to become blocked during major runoff events.

In the lower reach downstream of 47 Street, there are 11 crossings: a traffic bridge on Old Airport Road, and 9 culvert crossings and one footbridge crossing serving the golf course. Of the 9 golf course culvert crossings, only one, with a 1750 x 1000 arch culvert, has a relatively unobstructed flow area. The other eight crossings have culverts of 800 mm diameter or less with all but one having either a screen or a gate at the inlet end. It is considered that all the culverts at these eight crossings would be, or would become plugged during major runoff events. It is understood that the purpose of the culvert screens and gates is to facilitate water ponding, storage and pumping for irrigation of the golf course.

The Old Airport Road bridge has a large established beaver dam in the waterway opening under the bridge. According to Town of Vegreville staff, this dam has always been rebuilt when removed (Ref. 2). It is considered that for flood risk mapping purposes, this beaver dam should be considered a permanent feature of the existing channel. It is understood that the golf course pumps water across this dam from upstream to provide additional irrigation water to replenish the storage in the downstream portions of the channel.

There is no natural outlet at the downstream end of the study reach. The original channel has been blocked by the northwest extension of 47 Street, with no culvert. Flow escapes the channel by overflowing the right bank 400 metres upstream of this dead end. Although an 800 ϕ and a 450 ϕ culvert have been installed at the overflow location, the inlet of the larger culvert is buried and presumed plugged and the smaller culvert is small and susceptible to plugging and thus considered not effective during major runoff events. Channel station 0 + 000 is located at the overflow location.

In the upper reach of the NDWT, there are nine crossings of which eight are culvert crossings and one is a weir or ford. The eight culvert crossings included four secondary roads, one highway, one railway and two access roads. The access roads have smaller culverts with considerably less capacity than the other crossings, however, they are assumed to remain unobstructed during major runoff events as there appears to be no significant source of debris immediately upstream.

The most upstream crossing, an access road, consists of a rock weir and ford built up across the channel. The primary purpose of this crossing appears to be to create ponding, possibly for irrigation water supply for the grounds of the nearby Environmental Centre.

Fences have been built across the NDWT channel or swale at various places.

5.0 CALCULATIONS OF FLOOD LEVELS

5.1 HEC-2 Program

Open-water flood water surface profiles were calculated using the HEC-2 program (version 4.6.2 released in May, 1991). This model was developed by the Hydrologic Engineering Centre of the U.S. Army Corps of Engineers. The HEC-2 model was designed for calculating water surface profiles for steady and gradually varied flow in natural or man-made channels. It was also designed for floodplain mapping, floodplain management, analysis of floodway encroachments, and flood insurance studies.

The HEC-2 program has the following capabilities:

- Calculation of subcritical and supercritical flow profiles.
- Modelling the effects of various obstructions such as bridges, culverts, weirs and structures in the channel or floodplain.
- Assessment of the effects of floodplain development, channel encroachment and channel improvements.

Additional features of the HEC-2 package include a formatted data editor, a data error checking program, standard and optional outputs, and plotting displays which facilitate the production of accurate water surface profile results.

The methodology applied in the program is based on the solution of the one-dimensional energy equation. Energy loss due to friction is calculated by Manning's equation. The computational procedure in the model is the standard step method which is a finite difference solution of the energy equation. The program solves the energy equation by iteration to attain an energy balance between each successive pair of cross sections and proceeds stepwise along the channel. Therefore, the HEC-2 program is very suitable for calculating water surface profiles in natural channels where substantial cross section survey data are available.

The program has the following limitations:

- The simulation is based on the assumption of one-dimensional flow which is not fully applicable for flow in rapid expansions and contractions and flow on large floodplains where flow can become two-dimensional and even three-dimensional.
- Flow is assumed to be steady.
- The flow boundaries of channel bed and banks are assumed to be rigid whereas the actual river channel boundaries are usually mobile to some degree, especially during floods.

- The effects of super-elevation at river bends cannot be simulated because uniform hydrostatic pressure distribution is assumed across each cross section.

- The total energy head is assumed to be the same across the cross section without considering the energy exchange between flows in the channel and the adjacent floodplain.

The one-dimensional steady-state simulation of floods using the HEC-2 program is considered adequate for this study because the flow is essentially steady; velocities are relatively low, the bed and banks are only slightly mobile; and the floodplains along the study reach are inundated during major flood events so that a constant energy head assumption across a cross section is reasonable.

Some of the cross sections used in this study exceeded the maximum 100 coordinate points per cross section imposed by the HEC-2 program. In those cases the cross-section was plotted and then smoothed over the floodplain segments to reduce the number of coordinate points.

A commercial copy of HEC-2 from Haestad Methods was used for this study.

5.2 Geometric Data

5.2.1 Cross-Section Data

Cross-section data for the Vermilion River and the NDWT were provided by Alberta Environmental Protection for use in the HEC-2 model. Generally, each cross-section included both the river channel and the adjacent flood plain. The flood plain segments of some cross-sections were found to be too short and were extended by SNC-LAVALIN, using a combination of the orthophoto mapping and a computer digital terrain model generated from data files provided by Alberta Environmental Protection.

Distances between cross-sections were obtained by tracing the flow lines for the main channel and for the left and right overbanks, on the 1:5000 orthophoto maps and then digitizing along the length of each flow line from section to section.

The spacing and alignment of all cross-sections were selected by Alberta Environmental Protection to represent the changes in channel and floodplain geometry, including changes in bed slope and cross-sectional shape, to sufficient detail to enable the HEC-2 model to calculate water surface profiles to the desired level of accuracy.

Vermilion River

A total of 69 surveyed cross-sections were provided for use in the HEC-2 model. Of these, 45 defined the channel geometry while 24 defined basic geometry at the ten crossings (see Table 4.1). Basic crossing geometry required for the HEC-2 model consists of two cross-sections, one immediately upstream and one immediately downstream of the crossing, plus specific dimensions and elevations, obtained by field survey, to define the geometry of the crossing structure itself. In many cases the structure geometry is partly defined by a third cross-section taken across the top of the structure which defines the bridge deck or the roadway across a culvert.

However, for input into the HEC-2 model, all the structure geometry (including any cross-section across the structure) is merged with the immediately upstream cross-section, so that each crossing is defined in the model by only two cross-sections.

For some of the crossings on the Vermilion River, the field survey crew determined by inspection that the immediately upstream and downstream cross-sections were practically the same. In such cases only the upstream cross-section was surveyed. The downstream cross-section was created for the model by duplicating the surveyed upstream cross-section. Five such cross-sections were synthesized. They have been identified by labelling them as cross-sections 101 through 105.

Table 5.1 summarizes the relationships between the cross-sections used in the model and those actually surveyed in the field.

TABLE 5.1

VERMILION RIVER CROSS-SECTION DATA BASE

Cross-Section used in HEC-2	Cross-Section Surveyed	Cross-Section Type
1-6	1-6	channel
101 8	8 8+7	D/S crossing U/S crossing
9-12	9-12	channel
13 15	13 15+14	D/S crossing U/S crossing
16-18	16-18	channel
102 20	20 20+19	D/S crossing U/S crossing
21-27	21-27	channel
28 30	28 30+29	D/S crossing U/S crossing
31-35	31-35	channel

Cross-Section used in HEC-2	Cross-Section Surveyed	Cross-Section Type
103 37	37 37+36	D/S crossing U/S crossing
38	38	channel
104 40	40 40+39	D/S crossing U/S crossing
41-42	41-42	channel
105 44	44 44+43	D/S crossing U/S crossing
45-47	45-47	channel
48 50	48 50+49	D/S crossing U/S crossing
51-55	51-55	channel
68 69	68 69	D/S crossing U/S crossing
56-59	56-59	channel
60 62	60 62+61	D/S crossing U/S crossing
63-67	63-67	channel

North Drain West Tributary

A total of 99 surveyed cross-sections were provided for use in the HEC-2 model. Of these, 49 defined the channel geometry and 50 defined geometry at the 21 crossings (see Table 4.2). For input into the HEC-2 model, the cross-section data had to be handled in the same ways as for the Vermilion River. In addition, to satisfy HEC-2 model requirement that these be at leat one cross-section defining the channel geometry between crossings, a cross-section had to be generated in some locations by duplication of a nearby representative surveyed section. A total of 28 synthetic cross-sections were used. They have been identified by labelling them as cross-sections 101 through 128.

Table 5.2 summarizes the relationships between the cross-sections used in the model and those actually surveyed in the field.

TABLE 5.2

NORTH DRAIN WEST TRIBUTARY CROSS-SECTION DATA BASE

Cross-Section used in HEC-2	Cross-Section Surveyed	Cross-Section Type
128	99	channel
99 97	99 97+98	D/S crossing U/S crossing
(1) 2-6	2-6	channel
101 8	8 8+7	D/S crossing U/S crossing
102	8	channel
103 10	10 10+9	D/S crossing U/S crossing
11	11	channel
104 13	13 13+12	D/S crossing U/S crossing
105	13	channel
106 15	15 15+14	D/S crossing U/S crossing
107	15	channel
108 17	17 17+16	D/S crossing U/S crossing
109	17	channel
110 19	17 19+18	D/S crossing U/S crossing
111	96	channel
(2) 112 96	96 96+95	D/S crossing U/S crossing
113	23	channel
114 23	23 23+22	D/S crossing U/S crossing
115	28	channel

Cross-Section used in HEC-2	Cross-Section Surveyed	Cross-Section Type
116 25	25 25+24	D/S crossing U/S crossing
117	28	channel
118 27	27 27+26	D/S crossing U/S crossing
28 127	28 32	channel channel
29 31	29 31+30	D/S crossing U/S crossing
126 32-36	32 32-36	channel channel
119 38	38 38+37	D/S crossing U/S crossing
39-41	39-41	channel
120 43	43 43+42	D/S crossing U/S crossing
44-48	44-48	channel
121 50	50 50+49	D/S crossing U/S crossing
51-56	51-56	channel
(3) 57-60	57-60	channel
61	61	channel
122 63	63 63+62	D/S crossing U/S crossing
123	63	channel
124 65	63 65+64	D/S crossing U/S crossing
66-67	66-67	channel
125 69	69 69+68	D/S crossing U/S crossing
70-71	70-71	channel
72 74	72 74+73	D/S crossing U/S crossing
75	75	channel

Cross-Section used in HEC-2	Cross-Section Surveyed	Cross-Section Type
76 78	76 78+77	D/S crossing U/S crossing
(4) 79-89	79-89	channel
(5) 90-94	94-94	channel

Notes:
1. Cross-Section 1 not used
2. Cross-Sections 95, 96 replace cross-sections 20, 21 due to crossing replacement.
3. Cross-Sections 57-60 are for Swale A.
4. A weir at cross-section 82 was modelled as a rise in the channel bed.
5. Cross-Sections 90-94 are for the north loop of a split channel; the north loop does not convey modelled flows.

5.2.2 Bridges, Culverts and Other Crossings

The Vermilion River through the study reach has nine bridge crossings and one crossing consisting of 8 blocked culverts. The NDWT through the study area has two bridge crossings, eighteen culvert crossings of which nine are blocked, and one rock weir which functions as an access crossing. All the crossings are listed in Tables 4.1 and 4.2. The crossing geometry was defined by the surveyed cross-sections supplemented by field measurements of specific bridge or culvert dimensions and elevations. Additional data were obtained for the CNR bridge crossing and for the Highway 16 and 47 Street bridge crossings of the Vermillion River from Canadian National Railways and from Alberta Transportation and Utilities, respectively.

All the bridge crossings were modelled using the special bridge routine available in HEC-2. All the functional culvert crossings were modelled using the special culvert routine. The crossings with blocked culverts were modelled using the special bridge routine with the waterway opening set to an insignificantly small value (0.01 sq.m). The rock weir crossing on the NDWT at Station 11+540 was modelled as a rise in the channel, using the surveyed cross-sections, rather than as a crossing structure.

5.3 Hydraulic Parameters

5.3.1 Expansion and Contraction Coefficients

When channel flow expands or contracts to accommodate itself to changes in channel cross-section as it moves downstream, energy losses occur. These losses are computed in the HEC-2 program by multiplying the absolute difference in the velocity head (kinetic energy) between successive cross sections by an expansion or contraction coefficient. These coefficients are a measure of the efficiency with which kinetic and potential energy is converted.

A coefficient value of zero indicates no energy conversion loss; a value of unity indicates complete loss. Conversion of potential to kinetic energy is generally more efficient than kinetic to potential; therefore the contraction coefficient is generally smaller (less loss) than the expansion coefficient. Energy conversion is also more efficient if the change is gradual; abrupt changes are less efficient.

For this study, the coefficients as shown in Table 5.3 were adopted, based on the HEC-2 User's Manual and the technical literature:

TABLE 5.3

EXPANSION AND CONTRACTION COEFFICIENTS

	Expansion Coefficient	Contraction Coefficient
Channel Cross Sections	0.3	0.1
Bridge Transitions	0.5	0.3
Culvert Transitions	1.0	0.9

Relatively high values for expansion and contraction coefficients were selected for culverts, since all instances of functioning culverts (i.e. those not plugged during runoff events) are located on the NDWT, which has a very wide flood channel relative to the culverts, constituting very abrupt transitions with inefficient energy conversion.

5.3.2 Manning's Roughness

The basic equation used by HEC-2 to calculate flow is Manning's Equation. Manning's Equation relates the flow's potential and kinetic energy with channel slope, cross-section geometry and hydraulic roughness. Channel slope and cross-section geometry are determined by surveys; the hydraulic roughness, known as the Manning roughness coefficient "*n*", must be estimated or determined indirectly by back-calculation of the Manning Equation for known conditions of discharge.

The hydraulic roughness, which is a measure of the resistance to flow, is highly variable and depends on numerous factors including the bed material roughness, channel vegetation, degree of meandering and channel bends, cross-sectional shape, and stage of flow. Selection of a channel roughness value is generally the most subjective step in development of a HEC-2 model. It is therefore highly desirable to calibrate the model by comparing HEC-2 model computed water levels with water levels observed in the field, and adjusting the model *n* value or values so as to duplicate observed conditions.

In this study, Manning's *n* values for the Vermilion River were calibrated by using high water observations from 1983, and results from a previous calibration based on 1974 flood levels, reported in an earlier study (Ref. 1). The calibration procedure and results are presented in Section 5.4.

For the NDWT, Manning's *n* values could not be calibrated as there were no recorded high water levels available. Instead, *n* values were adopted on the basis of comparison with the Vermilion River channel. The HEC-2 model was then calibrated by adjusting the 100-year discharge so that calculated flood levels matched the 1974 flood levels as recorded on aerial photos. The calibration procedure and results are presented in Section 5.4.

Floodplain roughness coefficients were selected on the basis of the earlier study (Ref. 1) and the technical literature. Model calibration for floodplain roughness was not possible because of a lack of detailed flood level and discharge observations. The following range of *n* values used for the floodplain are shown in Table 5.4

TABLE 5.4

FLOODPLAIN *n* VALUES

Channel	Floodplain *n* values
Vermilion River	0.07 - 0.18
NDWT - lower reach	0.03 - 0.10
NDWT - upper reach	0.04 - 0.06

These *n* values reflect varying overbank conditions ranging from golf course fairways and cultivated fields to heavy bush with fallen deadwood.

5.4 Model Calibration

5.4.1 Vermilion river

Methodology

A previous study (Ref. 1) carried out by Alberta Environment in 1983 had included calibration of a HEC-2 model for the Vermilion River using the 1974 flood water level observations. The results of that calibration were taken as a starting point. The adopted channel *n* values are shown in Table 5.5

TABLE 5.5

VERMILION RIVER CHANNEL *n* VALUES

Channel Characteristics	*n* Value
unmaintained channel	0.067
maintained channel	0.057
recent channel cutoffs	0.035

The 1983 study also tested the variation of *n* with stage, using observed water levels for various discharges at the Highway 16 bridge. It was found that calculated water levels were close to the observed levels, for a single value of *n* (see Curve 1, Figure 3.6). It was therefore concluded that Manning's *n* did not vary significantly with stage; that conclusion has been retained for the present study.

The first step in calibrating the current HEC-2 model was to use the same *n* values as used in the 1983 study for both channel and floodplain, the same crossings (i.e. without the two footbridges in Kinsmen Park) and the 1983 values for the 100-yr flood ($87.8m^3$/sec) and the 2-year flood ($10.8m^3$/sec.) which differ from the present values of $73.0m^3$/sec and $10.0m^3$/sec, respectively. This step resulted in water surface profiles on the whole somewhat lower than the 1983 study profiles see (Figure 5.1). A review of the channel geometry indicated that these differences were caused by differences in channel cross sections and bed elevations.

The 1983 study had used cross-sections surveyed in 1981 (Station 0+000 to Station 2+500) and 1975 (Station 3+100 to Station 8+000). The present study uses cross-sections surveyed in 1991. Natural erosion and deposition, accelerated locally by construction in 1977 of five meander loop cutoffs between Station 4+300 and Station 6+750, appears to have resulted in channel changes as summarized in Table 5.6 and illustrated in Figure 5.2.

TABLE 5.6

VERMILION RIVER CHANNEL CHANGES (1975/81 - 1991)

Reach	Channel Change	Comments
Sta 7+050 to 7+950	erosion; larger cross-section	• Figure 5.2(a) • bed lowering (Fig. 5.1) • bank erosion protection required (Sec. 4.4.1)
Cutoffs between Sta. 4+300 to 6+750	deposition; narrower cross-section	• Figure 5.2(b) • cut-offs constructed wider than needed
Sta 0+000 to 3+800	erosion; larger cross-section	• Figure 5.2(c) • bed lowering (Fig. 5.1)

The second calibration step was to use the 1983 high water observations taken at a discharge of 21.0 m^3/sec. and adjust *n* values in the HEC-2 model to achieve similarity for calculated water levels. This involved adopting a consistent channel *n* value of 0.057 through the former cutoffs, as these were now similar to the natural channel, and revising the floodplain *n* for the lower reach downstream of Old Airport Road from 0.04 to 0.09. A comparison of the observed and calculated water levels for the 1983 flood event of $21.0m^3$/sec is given in Table 5.7.

TABLE 5.7
VERMILION RIVER 1983 FLOOD EVENT
COMPARISON OF OBSERVED AND CALCULATED LEVELS

Location	Observed Water Level (m)	Calculated Water Level (m)	Difference (m)
Highway 16	632.85	632.70	-0.15
CNR	632.50	632.39	-0.11
43 Street	630.87	631.09	+0.22
61 Avenue	630.37	630.33	-0.04
Old Airport Road	630.02	629.97	-0.05

Final calibration results, including channel *n* values are shown in Figure 5.8. Note that the 1983 study reach did not extend upstream of Highway 16.

Results

HEC-2 model calibration was achieved by using channel and floodplain roughness values obtained from the 1983 study, revised to simulate 1983 high water observations and to reflect current channel and floodplain conditions.

The resulting channel and floodplain *n* values are given in Table 5.8. Left and right overbanks are based on an orientation facing downstream.

TABLE 5.8

VERMILION RIVER CALIBRATED MANNING'S *n* VALUES

Reach (cross-sections)	Left Overbank	Channel	Right Overbank
1 - 8	0.09	0.067	0.09
9	0.09	0.057	0.08
10	0.15	0.057	0.10
11	0.08	0.057	0.12
12	0.13	0.057	0.14
13 - 15	0.13	0.057	0.18
16	0.16	0.057	0.10
17	0.14	0.057	0.11
18	0.12	0.057	0.12
102 - 20	0.13	0.057	0.08
21	0.16	0.057	0.10
22	0.17	0.057	0.14

Reach (cross-sections)	Left Overbank	Channel	Right Overbank
23	0.12	0.057	0.16
24	0.12	0.057	0.14
25	0.09	0.057	0.04
26 - 27	0.10	0.057	0.11
28 - 30	0.10	0.057	0.10
31	0.09	0.057	0.13
32 - 34	0.09	0.057	0.09
35 - 40	0.10	0.057	0.16
41 - 45	0.12	0.057	0.11
46	0.07	0.057	0.12
47 - 54	0.09	0.057	0.09
55 - 67	0.05	0.057	0.05

5.4.2 North Drain West Tributary

Methodology

No high water level observations are available for floods on the North Drain West Tributary (NDWT). The HEC-2 model could thus not be calibrated by varying Manning's *n* in the usual manner. Instead, Manning's *n* values were selected for the NDWT channel and floodplain, based on comparison with the Vermilion River, and the technical literature. The discharge through the lower reach of the NDWT (with all golf course crossings removed) was then varied until the calculated flood limits approximated those shown on the aerial photography of the 1974 flood which is estimated to have been a 100-year flood event. The key constraints were that there should be no overtopping of the Old Airport Road Bridge or the 47 Street and 50 Street culvert crossings, as per the flood photos. The resulting discharge of 3.30 m^3/sec. was taken to be the 100-year flood peak.

Results

The selected Manning's *n* values for the NDWT channel and floodplain are listed in Table 5.9.

A value of n = 0.070 was selected for the lower reach of the NDWT channel where it consists of a previous channel of the Vermilion River. This is slightly higher than the value of 0.067 used for the lower, unmaintained reach of the present Vermilion River. A value of n = 0.050 was selected for the upper, swale-like reach of the NDWT.

TABLE 5.9

NDWT MANNING'S *n* VALUES

Reach (cross-sections)	Left Overbank	Channel	Right Overbank
128 - 6	0.04	0.070	0.04
101 - 8	0.03	0.070	0.10
102 - 10	0.05	0.070	0.10
11 - 13	0.10	0.070	0.04
105 - 15	0.10	0.070	0.10
107 - 17	0.03	0.070	0.10
109 - 19	0.07	0.070	0.07
111 - 96	0.10	0.070	0.04
113 - 23	0.03	0.070	0.03
115 - 25	0.08	0.070	0.03
117 - 27	0.03	0.070	0.03
28	0.10	0.070	0.03
127 - 31	0.07	0.070	0.04
126 - 32	0.06	0.070	0.08
33 - 38	0.04	0.070	0.06
39	0.06	0.050	0.06
40 - 50	0.04	0.050	0.04
51 - 89	0.06	0.050	0.06

The calibrated value of the 100-year flood peak of 3.30 m^3/sec. is 57% of the 5.74 m^3/sec. recommended in the Hydrology Report (see Section 3.1.2), a value based on direct linear area transfer from the Vermilion River.

The selection of 3.30m^3/sec. was checked by review of the available hydrologic data provided in the Hydrology Report, which includes three annual instantaneous peak flows (Table 3.3). Two of those peaks were non-coincident with the Vermilion River annual peaks. The 1980 peak however was coincident, and shows a unit peak flow of 0.0025 $m^3/sec/km^2$, equal to 62.5% of the Vermilion River unit peak flow. This ratio compares well with the 57% ratio adopted. Consequently the 50-, 20-, 10-, 5- and 2-year flood peaks were reduced by the same ratio, as shown in Table 3.4.

Because of the relatively small drainage area of the NDWT, some variation in discharge occurs through the study reach. Table 5.10 summarizes the discharges used for the various sub-reaches.

TABLE 5.10

NDWT DESIGN FLOOD DISCHARGES (in m^3/sec.)

Flood Return Period (yrs)	Channel Reach (Cross-Sections) 89-82	82-56	60-56 (Swale A)	56-128
100	3.00	3.20	0.10	3.30
50	2.47	2.63	0.08	2.71
20	1.76	1.88	0.06	1.94
10	1.32	1.40	0.05	1.45
5	0.91	0.97	0.02	0.99
2	0.43	0.44	0.01	0.45

5.5 Computed Water Surface Profiles

5.5.1 Vermilion River

The calibrated HEC-2 model was used to calculate water surface profiles for the annual instantaneous peak flows having return periods of 100, 50, 20, 10, 5 and 2 years, for existing channel conditions. The profiles are shown in Figure 5.3, which also shows the locations and elevations of all the crossings.

The calculated water surface elevations for each design discharge at each cross-section are also shown in Table 5.11.

All the traffic bridges are above 100-year flood levels, except for the Old Airport Road bridge and the CNR bridge, both of which have their bottom chord just below the 100-year flood level. The two footbridges in Kinsmen Park are below the 100-year flood level.

The possibility of overbank flows spilling from the Vermilion River into the NDWT in the Airport area was recognized and investigated. It was found that Vermilion River water levels for the 100-year flood would be slightly below the spillover level.

5.5.2 North Drain West Tributary

The HEC-2 model was used with the calibrated discharges for the 100, 50, 20, 10, 5 and 2 year return period floods to calculate water surface profiles for existing channel conditions. The profiles are shown on Figure 5.4 and tabulated in Table 5.12.

The profile plot shows that, except for portions of the upper reaches, water levels are almost entirely controlled by the outlet and the crossings, as indicated by almost horizontal backwater. At the crossings, culverts are either plugged, forcing all flow to weir-type flow over the top of the crossing, or culverts act as orifice restrictions through inlet control. Under such flow conditions water levels are very insensitive to channel roughness values. Note that water levels could be reduced significantly by reconstruction of the culvert crossings with a lower crossing profile which would function as a broad-crested weir to pass high flows.

Because of various culvert crossings installed in the golf course area, most of which are considered non-functional during large runoff events (see Section 4.4.2), flood levels become backed-up to the extent that spill occurs across the right overbank floodplain through the airport area and into the Vermilion River. No refinements to reflect this condition were made to either the Vermilion River or the NDWT HEC-2 model, for the following reasons.

For the Vermilion River model, the amount of flow being added by spillover from the NDWT would be very small (perhaps 1% or 2%) and would have a negligible effect on Vermilion River water levels. For the NDWT, the amount of flow lost by spillover could be significant, but the effect on water levels would be small, as water levels are basically controlled by weir-type overflow of crossings, with large changes in discharge resulting in relatively small changes in water level. Such small changes have been ignored; the adopted approach is conservative.

Table 5.11
Vermilion River Water Surface Profiles

Section	Station	Computer Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
1	0+000	628.20	628.85	629.18	629.35	629.55	629.60
2	0+615	628.33	629.06	629.35	629.50	629.67	629.74
3	1+245	628.48	629.26	629.56	629.72	629.89	629.97
4	1+523	628.60	629.40	629.68	629.85	630.03	630.13
5	1+998	628.78	629.61	629.90	630.09	630.29	630.40
6	2+691	629.09	629.87	630.19	630.40	630.59	630.70
101	3+128	629.22	630.01	630.36	630.59	630.77	630.88
8	3+136	629.22	630.01	630.36	630.60	630.80	630.93
9	3+349	629.28	630.09	630.44	630.69	630.89	631.01
10	3+762	629.41	630.20	630.56	630.80	631.02	631.15
11	3+978	629.46	630.26	630.63	630.88	631.11	631.26
12	4+195	629.53	630.35	630.73	630.99	631.26	631.42
13	4+255	629.55	630.38	630.76	631.03	631.30	631.47
15	4+266	629.55	630.38	630.76	631.03	631.30	631.48
16	4+324	629.57	630.41	630.80	631.08	631.38	631.57
17	4+489	629.59	630.44	630.84	631.14	631.45	631.66
18	4+589	629.60	630.45	630.85	631.15	631.48	631.68
102	4+801	629.62	630.47	630.88	631.19	631.52	631.74
20	4+813	629.62	630.47	630.88	631.19	631.52	631.74
21	5+107	629.68	630.54	630.96	631.28	631.63	631.85
22	5+292	629.77	630.64	631.07	631.40	631.76	632.00
23	5+552	629.88	630.73	631.17	631.52	631.91	632.16

Table 5.11
Vermilion River Water Surface Profiles

Section	Station	Computer Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
24	5+750	630.00	630.84	631.28	631.64	632.05	632.31
25	5+932	630.08	630.92	631.37	631.73	632.16	632.44
26	6+093	630.16	630.99	631.44	631.82	632.26	632.55
27	6+276	630.30	631.09	631.54	631.92	632.38	632.67
28	6+329	630.35	631.14	631.60	631.98	632.44	632.73
30	6+339	630.35	631.15	631.60	631.98	632.44	632.74
31	6+400	630.44	631.24	631.70	632.09	632.56	632.87
32	6+529	630.66	631.41	631.84	632.21	632.69	633.00
33	6+626	630.81	631.57	632.00	632.38	632.84	633.14
34	6+747	630.96	631.74	632.18	632.56	633.04	633.34
35	6+827	631.06	631.83	632.27	632.65	633.14	633.45
103	6+916	631.19	631.95	632.39	632.77	633.26	633.57
37	6+919	631.19	631.95	632.40	632.77	633.29	633.62
38	7+010	631.28	632.07	632.53	632.92	633.43	633.75
104	7+067	631.32	632.11	632.57	632.96	633.47	633.78
40	7+068	631.33	632.17	632.61	632.98	633.47	633.78
41	7+168	631.44	632.30	632.74	633.10	633.59	633.90
42	7+316	631.58	632.43	632.88	633.24	633.72	634.03
105	7+423	631.69	632.53	632.97	633.33	633.79	634.08
44	7+429	631.69	632.53	632.97	633.33	633.79	634.09
45	7+456	631.70	632.54	632.98	633.34	633.80	634.10
46	7+626	631.81	632.62	633.06	633.42	633.88	634.17

Table 5.11
Vermilion River Water Surface Profiles

Section	Station	Computer Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
47	7+866	631.94	632.78	633.23	633.60	634.08	634.38
48	7+928	631.97	632.82	633.26	633.63	634.10	634.39
50	7+951	631.97	632.82	633.26	633.63	634.10	634.39
51	8+073	632.04	632.91	633.36	633.74	634.22	634.52
52	8+257	632.13	633.00	633.44	633.81	634.27	634.56
53	8+512	632.28	633.14	633.57	633.94	634.37	634.63
54	9+420	632.55	633.45	633.87	634.24	634.59	634.79
55	10+270	632.84	633.71	634.06	634.35	634.64	634.82
68	10+702	633.02	633.83	634.14	634.39	634.65	634.82
69	10+711	633.02	633.83	634.15	634.40	634.65	634.82
56	11+142	633.18	634.01	634.33	634.54	634.68	634.84
57	12+297	633.46	634.33	634.53	634.65	634.76	634.88
58	12+779	633.52	634.40	634.61	634.73	634.86	634.97
59	13+000	633.56	634.43	634.65	634.79	634.94	635.06
60	13+103	633.57	634.44	634.66	634.80	634.96	635.08
62	13+114	633.57	634.44	634.66	634.81	634.96	635.09
63	13+170	633.58	634.44	634.67	634.82	634.98	635.11
64	13+605	633.72	634.61	634.90	635.15	635.46	635.65
65	13+820	633.83	634.71	635.02	635.26	635.58	635.76
66	14+168	633.97	634.83	635.13	635.35	635.65	635.83
67	14+287	633.99	634.85	635.15	635.38	635.67	635.85

Table 5.12
North Drain West Tributary Water Surface Profiles

Section	Station	Computed Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
128	0+000	629.60	629.65	629.70	629.75	629.80	629.90
99	0+010	629.79	629.81	629.79	629.79	629.81	629.90
97	0+019	629.90	629.94	629.96	629.98	630.01	630.03
2	0+355	629.90	629.94	629.96	629.99	630.02	630.04
3	0+756	629.90	629.94	629.97	630.00	630.03	630.06
4	1+548	629.90	629.95	629.98	630.01	630.07	630.11
5	2+234	629.90	629.95	629.99	630.04	630.10	630.16
6	3+170	629.91	629.98	630.04	630.11	630.21	630.29
101	3+646	630.49	630.46	630.47	630.47	630.48	630.48
8	3+651	630.60	630.66	630.70	630.74	630.79	630.82
102	3+676	630.60	630.66	630.70	630.74	630.79	630.82
103	3+714	630.60	630.66	630.70	630.74	630.79	630.82
10	3+719	630.63	630.69	630.72	630.76	630.81	630.84
11	4+135	630.63	630.69	630.73	630.77	630.82	630.86
104	4+374	630.63	630.69	630.73	630.77	630.83	630.87
13	4+381	630.64	630.69	630.74	630.78	630.83	630.87
105	4+434	630.64	630.69	630.74	630.78	630.83	630.87
106	4+485	630.64	630.70	630.74	630.78	630.83	630.87
15	4+489	630.64	630.70	630.74	630.78	630.83	630.87
107	4+589	630.64	630.70	630.74	630.78	630.84	630.88
108	4+811	631.30	631.31	631.34	631.31	631.35	631.30
17	4+821	631.42	631.48	631.51	631.54	631.58	631.60
109	5+001	631.42	631.48	631.51	631.54	631.58	631.61
110	5+183	631.42	631.48	631.51	631.54	631.58	631.61

Table 5.12
North Drain West Tributary Water Surface Profiles

Section	Station	Computed Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
19	5+188	631.42	631.48	631.51	631.54	631.58	631.61
111	5+248	631.42	631.48	631.51	631.54	631.58	631.61
112	5+271	631.42	631.48	631.51	631.54	631.58	631.61
96	5+275	631.43	631.48	631.52	631.55	631.58	631.61
113	5+305	631.43	631.48	631.52	631.55	631.58	631.61
114	5+335	631.43	631.48	631.52	631.55	631.59	631.61
23	5+342	631.43	631.48	631.52	631.55	631.59	631.61
115	5+458	631.43	631.48	631.52	631.55	631.59	631.61
116	5+807	631.43	631.48	631.52	631.55	631.59	631.62
25	5+814	631.43	631.49	631.52	631.55	631.59	631.62
117	5+864	631.43	631.49	631.52	631.55	631.59	631.62
118	5+920	631.43	631.49	631.52	631.55	631.59	631.62
27	5+924	631.43	631.49	631.52	631.55	631.60	631.62
28	6+132	631.43	631.49	631.52	631.55	631.60	631.63
127	6+242	631.43	631.49	631.52	631.56	631.60	631.63
29	6+353	631.43	631.49	631.52	631.56	631.61	631.64
31	6+362	631.43	631.49	631.52	631.56	631.61	631.65
126	6+387	631.43	631.49	631.53	631.57	631.63	631.67
32	6+414	631.43	631.49	631.53	631.57	631.63	631.67
33	6+655	631.43	631.49	631.53	631.57	631.64	631.68
34	6+923	631.43	631.49	631.54	631.58	631.64	631.69
35	7+090	631.43	631.50	631.54	631.58	631.65	631.69
36	7+257	631.43	631.50	631.54	631.59	631.65	631.70
119	7+315	631.44	631.50	631.55	631.59	631.66	631.71

Table 5.12
North Drain West Tributary Water Surface Profiles

Section	Station	Computed Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
38	7+334	631.44	631.54	631.63	631.75	632.11	632.19
39	7+392	631.46	631.60	631.73	631.88	632.11	632.19
40	7+565	631.46	631.60	631.74	631.89	632.12	632.19
41	7+742	631.47	631.61	631.74	631.89	632.12	632.19
120	7+837	631.55	631.65	631.76	631.90	632.12	632.20
43	7+855	631.63	631.90	632.11	632.33	632.72	633.05
44	7+903	631.68	631.98	632.21	632.45	632.84	633.18
45	8+151	631.70	631.99	632.21	632.45	632.84	633.18
46	8+227	631.82	631.99	632.22	632.45	632.84	633.18
47	8+548	632.28	632.20	632.24	632.46	632.85	633.18
48	8+843	632.60	632.76	632.80	632.67	632.85	633.18
121	8+985	632.90	632.96	633.03	633.48	633.18	633.20
50	9+012	632.94	633.11	633.29	633.76	633.84	634.10
51	9+062	632.96	633.16	633.36	633.82	633.95	634.22
52	9+255	632.97	633.16	633.36	633.82	633.95	634.22
53	9+496	633.07	633.21	633.38	633.83	633.95	634.22
54	9+768	633.26	633.40	633.50	633.84	633.96	634.23
55	9+961	634.00	634.04	634.07	634.07	634.09	634.24
56	10+109	634.25	634.33	634.38	634.41	634.46	634.43
61	10+177	634.39	634.44	634.49	634.51	634.56	634.62
122	10+197	634.71	634.78	634.79	634.79	634.79	634.79
63	10+202	634.76	634.93	634.85	634.83	634.86	634.87
123	10+209	634.77	634.93	634.85	634.83	634.86	634.87
124	10+217	634.77	634.93	634.85	634.84	634.86	634.87

Table 5.12
North Drain West Tributary Water Surface Profiles

Section	Station	Computed Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
65	10+225	634.77	634.94	634.91	634.94	635.06	635.17
66	10+324	634.78	634.97	634.95	635.00	635.14	635.26
67	10+427	634.80	634.98	634.98	635.04	635.17	635.28
125	10+485	634.85	635.03	635.08	635.15	635.27	635.36
69	10+516	634.87	635.08	635.15	635.26	635.43	635.56
70	10+647	635.14	635.26	635.33	635.41	635.55	635.67
71	10+789	635.45	635.50	635.51	635.51	635.55	635.65
72	10+872	635.62	635.86	636.01	636.03	636.01	636.02
74	10+890	635.63	635.93	636.09	636.11	636.13	636.15
75	10+999	635.65	635.96	636.09	636.11	636.13	636.15
76	11+112	635.66	635.96	636.09	636.12	636.24	636.35
78	11+121	635.99	636.46	636.48	636.49	636.68	636.87
79	11+255	636.06	636.46	636.48	636.49	636.69	636.87
80	11+403	636.14	636.46	636.48	636.50	636.69	636.87
81	11+531	636.36	636.47	636.49	636.51	636.69	636.88
82	11+540	636.75	636.80	636.82	636.85	636.88	636.91
83	11+550	636.78	636.85	636.88	636.92	636.96	637.00
84	11+704	636.78	636.84	636.88	636.92	636.97	637.00
85	11+969	636.98	637.04	637.08	637.11	637.16	637.19
86	12+244	637.09	637.18	637.24	637.28	637.35	637.39
87	12+443	637.43	637.46	637.49	637.52	637.57	637.59
88	12+650	638.07	638.10	638.11	638.13	638.14	638.14
89	12+876	638.28	638.35	638.40	638.45	638.49	638.53

Table 5.12
Swale A Water Surface Profiles

Section	Station	Computed Water Surface Elevation (m)					
		Q2	Q5	Q10	Q20	Q50	Q100
56	0+000	634.25	634.33	634.38	634.41	634.46	634.43
57	0+174	634.25	634.33	634.38	634.41	634.46	634.43
58	0+328	634.25	634.33	634.38	634.41	634.46	634.44
59	0+470	634.46	634.46	634.48	634.48	634.48	634.49
60	0+609	634.82	634.89	634.96	634.97	634.98	634.97

5.6 Model Sensitivity

5.6.1 Vermilion River

Downstream Water Level

Starting water levels at cross-section 1 of the HEC-2 model were selected on the basis of the 1983 study results, adjusted for channel changes to the present, and the shape of the profiles. The starting water levels are given in Table 5.13.

TABLE 5.13

VERMILION RIVER - CROSS-SECTION 1 WATER LEVELS

Return Period (yrs)	Discharge (m^3/sec.)	Water Level (m)
100	73	629.60
50	60	629.55
20	43	629.35
10	32	629.18
5	22	628.85
2	10	628.20

The sensitivity of the profile calculations for the 100-year flood was tested by starting with water levels 0.20 and 0.40m above and below the selected level of 629.60m. The results are presented in Table 5.14 and Figure 5.5.

TABLE 5.14

VERMILION RIVER - 100 YEAR FLOOD PROFILE SENSITIVITY TO STARTING WATER LEVEL

	Water Level (m)					
Cross-Section	**1**	**2**	**3**	**4**	**5**	**6**
Selected W.L. + 0.40	630.00	630.03	630.13	630.23	630.44	630.71
Selected W.L. + 0.20	629.80	629.87	630.03	630.16	631.41	630.70
Selected W.L	629.60	624.74	629.97	630.13	630.40	630.70
Selected W.L. - 0.20	629.40	629.67	629.96	630.12	630.40	630.70
Selected W.L. - 0.40	629.20	629.69	629.96	630.13	630.40	630.70

It is evident that the profile is not very sensitive to starting water level, as a difference of $\pm$ 0.40 m diminishes to 0.1m or less within 1500 metres, at cross-section 4, and to 0.01 m or less within 2690 metres, at Cross-section 6.

Manning's Roughness

Manning's Equation used by HEC-2 to calculate water surface profiles is quite sensitive to the value of Manning's *n*. The model was therefore run for values of *n* which were varied in the range of 80% to 120% of the calibrated values. Table 5.15 lists the numerical values of the channel *n* values tested.

TABLE 5.15

VERMILION RIVER
CHANNEL *n* VALUES USED FOR SENSITIVITY TESTING

Percent Variation	80%	90%	100%	110%	120%
Sections 9 - 67	0.046	0.051	0.057	0.063	0.068
Section 1 - 8	0.054	0.060	0.067	0.074	0.080

One set of model runs was executed for variation of channel *n* values only; a second set of model runs was carried out for variation of both channel and floodplain *n* values. A representative summary of the results is given in Table 5.16.

The results indicate that computed water levels differ by up to -0.33 m and +0.51 m for variations of 80% and 120% of the calibrated *n* values, respectively. These results underline the importance of proper calibration of *n* values to obtain correctly computed flood water levels. Calibration of channel *n* values was achieved in this study by reference to high water mark observations during two different flood events.

Most of the differences in computed water levels are due to channel *n* variation; floodplain *n* variation accounts for only 0.06 m or less of the total difference in all cases. The lack of specific calibration for floodplain *n* values is thus considered to be acceptable.

TABLE 5.16

VERMILION RIVER - EFFECT OF VARIATION OF *n* VALUES ON COMPUTED WATER LEVELS

Section	Channel Alone or with Floodplain	Variation of *n* as a % 80%	90%	100%	110%	120%	Water Level Variation (m)
		Computed Water Level (m)					
6	ch	630.62	630.66	**630.70**	630.73	630.76	-.08/+.06
	ch+fp	630.58	630.64	**630.70**	630.76	630.80	-.12/+.10
10	ch	631.04	631.10	**631.15**	631.18	631.22	-.11/+.07
	ch+fp	631.01	631.09	**631.15**	631.20	631.25	-.14/+.10
18	ch	631.49	631.59	**631.68**	631.77	631.85	-.19/+.17
	ch+fp	631.47	631.58	**631.68**	631.78	631.87	-.21/+.19
26	ch	632.24	632.40	**632.55**	632.68	632.81	-.31/+.26
	ch+fp	632.24	632.40	**632.55**	632.69	632.82	-.31/+.27
34	ch	633.02	633.19	**633.34**	633.49	633.62	-.32/+.28
	ch+fp	633.01	633.18	**633.34**	633.49	633.63	-.33/+.29
38	ch	633.44	633.60	**633.75**	634.18	634.26	-.31/+.51
	ch+fp	633.43	633.60	**633.75**	634.19	634.26	-.32/+.51
47	ch	634.11	634.25	**634.38**	634.65	634.73	-.27/+.35
	ch+fp	634.08	634.23	**634.38**	634.67	634.76	-.30/+.38
54	ch	634.62	634.71	**634.79**	634.93	634.98	-.17/+.19
	ch+fp	634.59	634.69	**634.79**	634.95	635.03	-.20/+.24
58	ch	634.90	634.93	**634.97**	635.05	635.09	-.07/+.12
	ch+fp	634.84	634.91	**634.97**	635.08	635.14	-.13/+.17
66	ch	635.68	635.76	**635.83**	635.89	635.94	-.15/+.11
	ch+fp	635.64	635.73	**635.83**	635.92	635.99	-.19/+.16

5.6.2 North Drain West Tributary

Sensitivity testing of the HEC-2 model for the NDWT was not considered useful or necessary, for several reasons. First, calibration of the model for Manning's *n* was not carried out due to lack of high water mark data. Second, the main factors controlling water level profiles along the NDWT (except in portions of the upper reaches) are weir overflow and restricted culvert inlets, resulting in very flat backwater-type water surface profiles which are very insensitive to variations in *n* values. Third, the starting water level at the downstream limit of the model is controlled by weir flow and has a negligibly small range of variation.

5.7 Flood Frequency Maps

Flood frequency maps were prepared showing the extent of inundation, or the flood limits, on the orthophoto maps of the study area, for the 100-year, 50-year, and 10-year floods of the Vermilion River and the NDWT channel for present conditions.

Flood limits were determined by identifying the intersection points of the calculated water surface profile and ground levels, at each cross-section, and interpolation between cross-sections guided by the contours and surface features on the maps. The flood frequency maps are attached as Drawings 6005-101,-102 and -103.

The 100-year flood would cause significant overbank flooding in three main portions of the study area: the large meander loop complex of the Vermilion River between stations 8+700 and 12+600 upstream of Highway 16, the Kinsmen Park area, and the Vegreville airport area. The main residential areas of Vegreville as well as the hospital, would not be inundated. Some properties may be affected by backflooding of old cut-off meander loops or oxbows and local tributary drains and swales.

The 50-year flood would cause flooding generally similar to that of the 100-year flood event, but at a lower depth of inundation. The 10-year flood would only cause minor inundation of the lower floodplain immediately adjacent to the channel, and some connected low areas.

The NDWT contributes significantly to flooding in the airport area. That flooding is largely caused by small and blocked culverts through the golf course forcing flows to overtop the crossings. Reconstruction of these crossings to provide a lower overflow elevation would reduce inundation significantly.

In the upper reach of the NDWT, flood flows cause the shallow channel to become very wide, but with no real overbank inundation. Some of the outbuildings at the Environmental Centre, and some other buildings to the north, located at the edge of a low swale, are affected by flooding on the NDWT.

Two locations were identified where shallow spillover into lower overbank areas could occur at the 50-year and higher floods. One location is on the left bank of the Vermilion River at 47 Street just downstream of the CNR bridge. The other location is also at 47 Street, adjacent to the golf course, where overbank flooding from the NDWT could spill over an apparent low spot on the roadway. These locations are identified on the maps.

6.0 FLOODWAY DETERMINATION

6.1 Terminology

The terms: "flood risk area", "floodway", and "flood fringe" are used in this study as defined according to the Alberta Environment publication "Hydrologic and Hydraulic Guidelines for Floodplain Delineation," 1990, (Ref. 5).

These terms have specific application to flood risk mapping studies carried out under the Canada-Alberta Flood Damage Reduction Program.

Flood Risk Area

The flood risk area is defined as the area which would be inundated by the 100 year flood. Within a flood risk area, a distinction is made between the floodway and flood fringe areas or zones, which are defined below.

Floodway

The floodway is defined as the stream channel and that portion of the floodplain required to convey the 100 year design flood under constricted conditions, assuming no conveyance capacity in the flood fringe. The floodway is where the waters are deepest, fastest and most destructive. New development within the floodway is discouraged.

Flood Fringe

The flood fringe is defined as the portion of the floodplain between the floodway and the outer boundary of the 100 year flood. Development in the flood fringe may be permitted provided that such development is adequately flood proofed.

6.2 Floodway Criteria

Based on Alberta Environment's 1990 Guidelines (Ref. 5) and specific site conditions in the study area, the following criteria were used to define the floodway limits. These criteria refer to conditions expected to occur for the 100 year flood.

Natural Channel

The floodway by definition should be no narrower than the natural channel. In HEC-2 modelling, the natural channel is identified on cross-section plots, and channel limits are coded as left bank and right bank stations.

Water Level Rise

When subcritical flood flow is constricted to a floodway area, the water level must rise in order for the same discharge to be conveyed. Such water level rise must not exceed 0.3 meters except possibly at isolated locations, and then only with justification. In some cases, where existing development would be threatened with inundation for a water level rise of less than 0.3 meter, a lower allowable rise should be considered.

Depth and Velocity Limits

In general, all areas where the depth of flooding exceeds 1 meter or where the flood flow velocity exceeds 1 meter per second shall become part of the floodway. However, in order to achieve a hydraulically smooth floodway boundary, some such areas may be made part of the flood fringe. In addition, areas where flood depths exceed 1 meter as a result of backwater conditions, and are wholly or largely ineffective in conveying flow, may be made part of the flood fringe.

High Channel Velocities

In river reaches where channel flow velocities are already excessive under existing conditions, encroachment should be minimized so as to not increase such velocities still more.

6.3 Methodology

The floodways for the Vermilion River and the NDWT were determined according to the following procedure.

First, the flow distribution option in the HEC-2 program was activated to calculate the velocity distributions at all cross sections for the 100 year flood event in natural conditions. The locations, where the 1 meter per second flow velocity first occurs by approaching from each side of the flood limits, were plotted on the 1:5,000 floodway criteria maps.

Similarly the 1 meter flow depth contours were plotted on the floodway criteria maps.

Thirdly, an initial floodway boundary was delineated based on the location of the 1m depth and 1m/sec velocity contours, the division of flow between channel and floodplain at each section and a subjective estimate of the constriction corresponding to the allowable or target water level rise.

Fourthly, smoothing of the floodway boundary determined in Step 3 was done to eliminate ineffective flow areas from the floodway and achieve a hydraulically smooth boundary.

Fifth, the HEC-2 model was run with the encroachments as delineated, using Method 1.

Sixth, the model output was then examined and the floodway delineation adjusted to more closely correspond to the target water level rise without violating the other criteria. This step was repeated iteratively until satisfactory results were obtained. The minimum permissible floodway was considered to be the natural channel as identified by the left bank and right bank stations on the cross-sections.

6.4 Results

The final floodway delineations for the Vermilion River and the NDWT are shown on Floodway Criteria Maps, Sheets, 1, 2 and 3 (Drawings 6005-201,-202,-203) which are included in the study file. The maps also show the 100 year flood limit for encroached conditions and the 1 m depth contour and 1 m/sec. velocity points.

Vermilion River

Table 6.1 lists the 100-year flood water levels at each cross-section, with and without constriction to the floodway. The table also shows which criterion governed the location of the floodway boundary at each cross-section for both the left bank (L) and the right bank (B).

The maximum permissible water level rise criterion governs at the downstream end of the study reach and along a short section of the upstream end. The main governing criterion is the 1 metre depth criterion. For much of the study reach, the 1 metre depth location corresponds roughly to the natural channel bank stations.

Because of the sensitivity of the Vegreville Hospital to inundation (the hospital was flooded in the 1974 flood) as well as considerable existing residential development in the area around the hospital, it was considered that the maximum permissible water level rise in this area should be limited to 0.1m. The reach subject to this more stringent criterion extends from the Cemetery (Section 24) to the CNR Bridge (Section 44). Due to the application of the 1 metre depth criterion as the governing criterion in this reach the maximum water level rise in this reach is 0.07 m.

Special consideration was given to the large meander loop complex between cross-section 53 and 58. Flood flows inundate the entire left overbank and a large fraction, up to 70% to 80% of the flow, is conveyed through it. It was therefore considered that the left overbank flow path should not be encroached upon beyond smoothing. The resulting maximum water level rise in this reach is 0.15 m

North Drain West Tributary

Table 6.2 lists the 100-year flood water levels at each cross-section, with and without constriction to the floodway, and identifies the criterion governing floodway boundary locations. Because of the fact that flood levels are largely controlled by the crossings and not the channel hydraulics, the governing criterion for setting the floodway boundary throughout the NDWT defaults to the channel banks, i.e. the floodway boundary is defined by the main channel.

In the lower reach downstream of 47 street (Section 36) the water level rise is very small: 0.03 m or less, except for a short sub-reach (Sections 13 - 107) where a rise of 0.22 m occurs. In the upper reach above 47 Street, a water level rise in the range of 0.10 m to 0.30 m predominates. The 0.30 m limit is exceeded at one location, at Section 43 representing the upstream end of the 50 Street culvert crossing, where a 0.35 m increase occurs. This is partly the result of the hydraulics at the culvert inlet and not the constriction of the channel alone; the immediately upstream reach has a water level rise of 0.23 m. It is therefore considered that this exception should be accepted.

In the reach upstream of the access road at Section 78, the channel is very wide and shallow and the cross-sections are spaced relatively far apart. For these conditions the HEC-2 model computations become somewhat unstable and lack of convergence is apparent in that some negative values for water level rise are reported. Physically such a result is not possible. All negative values can be taken practically to equal zero.

The secondary channel between Sections 74 and 89 was found to be above calculated water levels for the 100-year flood. Some inundation of the secondary channel occurs at its downstream end due to back-up of water from the main channel at Section 74.

Table 6.1
Vermilion River
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
1	629.60	629.8	0.20			L, R	
2	629.74	629.97	0.23			L, R	
3	629.97	630.24	0.27			L, R	
4	630.13	630.44	0.31			L, R	
5	630.40	630.71	0.31			L, R	
6	630.70	630.94	0.24				L, R
101	630.88	631.1	0.22				L, R
8	630.93	631.11	0.18				L, R
9	631.01	631.25	0.24				L, R
10	631.15	631.37	0.22				L, R
11	631.26	631.46	0.20		L		R
12	631.42	631.58	0.16		R		L
13	631.47	631.62	0.15		L, R		
15	631.48	631.62	0.14		L, R		
16	631.57	631.7	0.13		L		R
17	631.66	631.78	0.12		L, R		
18	631.68	631.8	0.12		L, R		
102	631.74	631.85	0.11		L, R		
20	631.74	631.85	0.11		L, R		
21	631.85	631.95	0.10		L		R
22	632.00	632.08	0.08		L, R		
23	632.16	632.23	0.07		L		R

Table 6.1
Vermilion River
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
24	632.31	632.37	0.06		L		R
25	632.44	632.48	0.04		L, R		
26	632.55	632.59	0.04		L, R		
27	632.67	632.7	0.03		L, R		
28	632.73	632.8	0.07		L, R		
30	632.74	632.8	0.06		L, R		
31	632.87	632.94	0.07		L, R		
32	633.00	633.06	0.06		L, R		
33	633.14	633.19	0.05		L, R		
34	633.34	633.38	0.04		L, R		
35	633.45	633.48	0.03		L, R		
103	633.57	633.6	0.03		L, R		
37	633.62	633.64	0.02		L, R		
38	633.75	633.77	0.02		L, R		
104	633.78	633.8	0.02		L, R		
40	633.78	633.8	0.02		L, R		
41	633.90	633.92	0.02		L		R
42	634.03	634.05	0.02		L		R
105	634.08	634.1	0.02		L, R		
44	634.09	634.11	0.02		L, R		
45	634.10	634.11	0.01		L, R		
46	634.17	634.19	0.02		L, R		

Table 6.1
Vermilion River
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
47	634.38	634.42	0.04		L, R		
48	634.39	634.46	0.07		L, R		
50	634.39	634.46	0.07		L, R		
51	634.52	634.59	0.07				L, R
52	634.56	634.66	0.10		L		R
53	634.63	634.78	0.15		L, R		
54	634.79	634.94	0.15				L, R
55	634.82	634.96	0.14		R		L
68	634.82	634.96	0.14				L, R
69	634.82	634.96	0.14				L, R
56	634.84	634.97	0.13				L, R
57	634.88	635	0.12		R		L
58	634.97	635.09	0.12		L		R
59	635.06	635.27	0.21		L		R
60	635.08	635.35	0.27			L, R	
62	635.09	635.35	0.26			L, R	
63	635.11	635.37	0.26			L, R	
64	635.65	635.77	0.12		R		L
65	635.76	635.86	0.10		L, R		
66	635.83	635.93	0.10				L, R
67	635.85	635.95	0.10				L, R

Table 6.2
North Drain West Tributary
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level: Natural Condition (m)	Water Level: Floodway Constriction (m)	Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits: Natural Channel	Depth 1 m	Water Level Rise	Smoothing
128	629.90	629.90	0.00	L, R			
99	629.90	629.90	0.00	L, R			
97	630.03	630.03	0.00	L, R			
2	630.04	630.04	0.00	L, R			
3	630.06	630.07	0.01	L, R			
4	630.11	630.11	0.01	L, R			
5	630.16	630.17	0.01	L, R			
6	630.29	630.32	0.03	L, R			
101	630.48	630.47	-0.01	L, R			
8	630.82	630.82	0.00	L, R			
102	630.82	630.82	0.00	L, R			
103	630.82	630.83	0.00	L, R			
10	630.84	630.85	0.01	L, R			
11	630.86	630.87	0.02	L, R			
104	630.87	630.89	0.02	L, R			
13	630.87	631.08	0.21	L, R			
105	630.87	631.09	0.22	L, R			
106	630.87	631.09	0.21	L, R			
15	630.87	631.09	0.22	L, R			
107	630.88	631.10	0.22	L, R			
108	631.30	631.33	0.02	L, R			
17	631.60	631.61	0.01	L, R			

Table 6.2
North Drain West Tributary
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
109	631.61	631.61	0.01	L, R			
110	631.61	631.61	0.01	L, R			
19	631.61	631.61	0.01	L, R			
111	631.61	631.61	0.01	L, R			
112	631.61	631.62	0.01	L, R			
96	631.61	631.62	0.01	L, R			
113	631.61	631.62	0.01	L, R			
114	631.61	631.62	0.01	L, R			
23	631.61	631.62	0.01	L, R			
115	631.61	631.62	0.01	L, R			
116	631.62	631.63	0.01	L, R			
25	631.62	631.63	0.01	L, R			
117	631.62	631.63	0.01	L, R			
118	631.62	631.64	0.01	L, R			
27	631.62	631.64	0.01	L, R			
28	631.63	631.64	0.02	L, R			
127	631.63	631.65	0.02	L, R			
29	631.64	631.66	0.02	L, R			
31	631.65	631.66	0.02	L, R			
126	631.67	631.69	0.02	L, R			
32	631.67	631.69	0.02	L, R			
33	631.68	631.70	0.02	L, R			

Table 6.2
North Drain West Tributary
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
34	631.69	631.71	0.03	L, R			
35	631.69	631.72	0.03	L, R			
36	631.70	631.75	0.05	L, R			
119	631.71	631.78	0.07	L, R			
38	632.19	632.34	0.15	L, R			
39	632.19	632.34	0.15	L, R			
40	632.19	632.34	0.15	L, R			
41	632.19	632.34	0.15	L, R			
120	632.20	632.34	0.15	L, R			
43	633.05	633.41	0.35	L, R			
44	633.18	633.41	0.23	L, R			
45	633.18	633.41	0.23	L, R			
46	633.18	633.41	0.23	L, R			
47	633.18	633.41	0.23	L, R			
48	633.18	633.41	0.23	L, R			
121	633.20	633.48	0.28	L, R			
50	634.10	634.37	0.27	L, R			
51	634.22	634.46	0.24	L, R			
52	634.22	634.46	0.24	L, R			
53	634.22	634.48	0.26	L, R			
54	634.23	634.50	0.27	L, R			
55	634.24	634.53	0.29	L, R			

Table 6.2
North Drain West Tributary
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level: Natural Condition (m)	Water Level: Floodway Constriction (m)	Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits: Natural Channel	Depth 1 m	Water Level Rise	Smoothing
56	634.43	634.69	0.26	L, R			
61	634.62	634.80	0.17	L, R			
122	634.79	634.88	0.09	L, R			
63	634.87	634.99	0.12	L, R			
123	634.87	634.99	0.12	L, R			
124	634.87	635.00	0.13	L, R			
65	635.17	635.21	0.05	L, R			
66	635.26	635.33	0.08	L, R			
67	635.28	635.40	0.12	L, R			
125	635.36	635.51	0.14	L, R			
69	635.56	635.68	0.12	L, R			
70	635.67	635.80	0.13	L, R			
71	635.65	635.84	0.19	L, R			
72	636.02	636.10	0.08	L, R			
74	636.15	636.35	0.21	L, R			
75	636.15	636.37	0.22	L, R			
76	636.35	636.47	0.12	L, R			
78	636.87	636.75	-0.12	L, R			
79	636.87	636.77	-0.10	L, R			
80	636.87	636.77	-0.10	L, R			
81	636.88	636.84	-0.04	L, R			
82	636.91	636.91	0.00	L, R			

Table 6.2
North Drain West Tributary
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
83	637.00	637.00	0.00	L, R			
84	637.00	637.00	0.00	L, R			
85	637.19	637.21	0.02	L, R			
86	637.39	637.49	0.10	L, R			
87	637.59	637.68	0.09	L, R			
88	638.14	638.06	-0.07	L, R			
89	638.53	638.66	0.13	L, R			

Table 6.2
North Drain West Tributary - Swale A
Floodway Water Level Rise & Criteria Governing Floodway Limits

Cross Section Number	Water Level		Increase in Water Level (m)	Controlling Criteria For Determining Floodway Limits			
	Natural Condition (m)	Floodway Constriction (m)		Natural Channel	Depth 1 m	Water Level Rise	Smoothing
-56	634.43	634.69	0.26	L, R			
57	634.43	634.69	0.26	L, R			
58	634.44	634.69	0.26	L, R			
59	634.49	634.69	0.21	L, R			
60	634.97	634.90	-0.07	L, R			

7.0 FLOOD RISK MAPS

7.1 General

Flood risk maps have been prepared showing the following information.

- The location and identifying number of all cross-sections used in the HEC-2 model to compute flood levels.
- The 100-year flood limits for encroached conditions.
- The floodway limits which define the boundary between the floodway and the flood fringe areas.
- The water surface elevation at each cross-section, calculated with the HEC-2 model, for the 100-year flood confined to the floodway

The flood risk maps are attached as Drawings 6005-301, -302, and -303.

The accuracy of the flood limits marked on the map is ± 0.5 metre vertical distance, as the topography is defined by the 1 metre contours provided. Computational errors due to input data errors, misestimation of roughness coefficients and limitations of the HEC-2 model are judged to be less than the ±0.5m contour mapping accuracy.

7.2 Areas Affected by the Floodway

Vermilion River

The floodway of the Vermilion River is largely confined to the main channel and the immediately adjacent overbank area throughout the study reach except for three areas:

- the airport area downstream of 61 Avenue
- Kinsmen Park
- The meander loop complex upstream of Highway 16

In the airport area, the floodway limits are located as two roughly parallel lines containing the meander width of the Vermilion River, widening as required to respect the 0.30 m water level rise criterion. The area within the floodway is all agricultural and without structures except for one house and garage located on the left bank just south of Old Airport Road. The airport runway is entirely outside of the floodway.

A portion of Kinsmen Park north of the CNR is within the floodway, but no buildings.

The interior (or left bank) of the meander loop complex upstream of Highway 16 is within the floodway, as are some of the right bank areas between individual meander loops. Several structures (which appear to be barns or sheds) located on these right bank areas are within the floodway.

North Drain West Tributary

The floodway of the NDWT is defined by the main channel throughout the entire study reach. There is no development within the floodway except for a stormwater pond and small pumphouse located between Highway 16 and 75 Street.

7.3 Areas Affected by the Flood Fringe

The main areas within the flood fringe are the airport and adjacent golf course areas and various undeveloped agricultural areas. The residential areas of Vegreville and the hospital are not affected. The specific developed areas affected are as follows:

- Vegreville Airport - the entire airport including the runway and all buildings and structures
- Golf Course - a large part of the golf course including all outbuildings, except for the main clubhouse and parking lot at the entrance which are not affected.
- Kinsmen Park - the portion of the park not in the floodway, including a building, is in the flood fringe area.
- Vermilion River north of Highway 16 - all or portions of five commercial, industrial or agricultural developments including buildings are within the flood fringe.
- NDWT upper reach - outbuildings and storage yard area at the Environmental Centre west of 75 Street.
- NDWT upper reach - structures and yard area of a development west of 75 Street north of the Environmental Centre.

SNC•LAVALIN INC.

Neil van der Gugten

Neil van der Gugten, M.A.Sc., P. Eng.
Project Manager

PROFESSIONAL ENGINEER
N. A. van der Gugten
ALBERTA

94-04-21

PERMIT TO PRACTICE
SNC - Lavalin Inc.
Signature
Date 94-04-21
PERMIT NUMBER: P 5645
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

8.0 REFERENCES

1. T.H. Winhold, Vegreville Floodplain Study, Alberta Environment, May 1983.

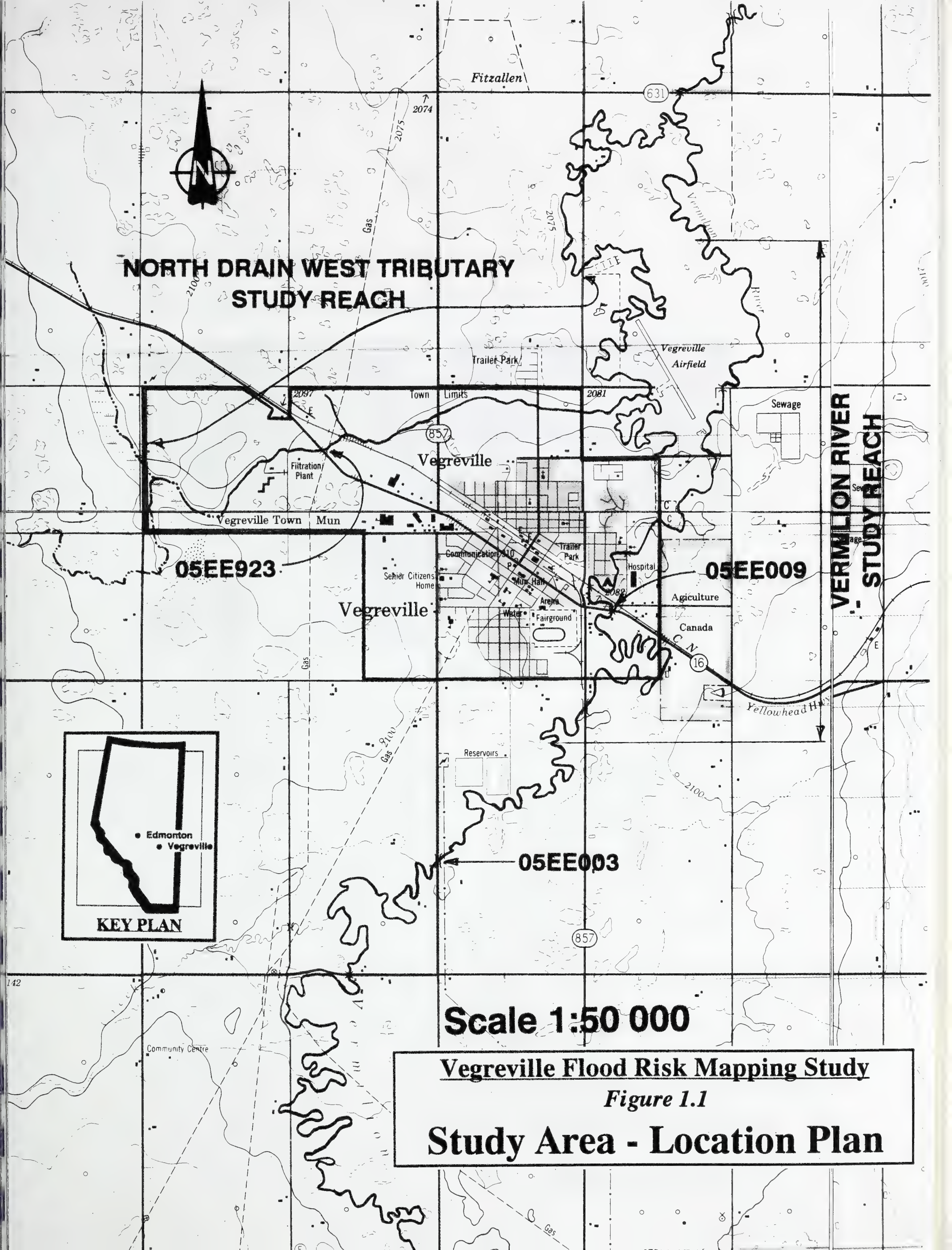
2. Personal Communication, Mike Dowhun and Orville Tebbutt, Town of Vegreville.

3. Personal Communication, Frank Slobosz, Water Survey of Canada, Calgary.

4. A. de Boer, Flood Frequency Analysis, Vegreville Floodplain Study, Alberta Environment, November 1991.

5. Hydrologic and Hydraulic Guidelines for Floodplain Delineation, Alberta Environment, November 1990.

FIGURES



Vegreville Flood Risk Mapping Study

Figure 1.1

Study Area - Location Plan

HWM	LOCATION	ELEVATION
Vermilion River VR 83-1	Hwy #16 Bridge at Vegreville	632.85 m (28 June 1983)

Looking u/s HWM VR 83-1 26 June 1983

BENCH MARK REFERENCE	LOCATION	ELEVATION
83E-205	SW-17-52-14-4	636.306 m

Description: Top of NE anchor bolt of 4 - NE corner of bridge over Vermilion River Hwy #16 at Vegreville.

Figure 3.1

Vermilion River 1983 Flood

Highway 16 Bridge

HWM	LOCATION	ELEVATION
Vermilion River VR 83-2	SEC-17-52-14-4 (CNR Bridge)	632.50 m (28 June 1983)

u/s side of bridge HWM VR 83-2 28 June 1983

Figure 3.2

Vermilion River 1983 Flood

CNR Bridge

d/s of bridge HWM VR 83-2 28 June 1983

HWM	LOCATION	ELEVATION
Vermilion River VR 83-3	Bridge north of hospital (43 st.)	630.87 m (28 June 1983)

u/s side of bridge HWM VR 83-3 26 June 1983

BENCH MARK REFERENCE	LOCATION	ELEVATION
83E-206	NW 1/4-17-52-14-W4	633.940 m

Description: Top of a piece of metal inset into concrete on NW corner of bridge approximately 300 m north of hospital.

Figure 3.3

Vermilion River 1983 Flood

43 Street Bridge

HWM	LOCATION	ELEVATION
Vermilion River VR 83-4	S 1/2-20-52-14-4 (61 Ave.)	630.37 m (28 June 1983)

Looking d/s HWM VR 83-4 26 June 1983

BENCH MARK REFERENCE	LOCATION	ELEVATION
83E-208	SEC-20-52-14-4	633.109 m

Description: Top of NW corner anchor bolt of four bolts in NW corner of bridge.

Figure 3.4

Vermilion River 1983 Flood

61 Avenue Bridge

HWM	LOCATION	ELEVATION
Vermilion River VR 83-5	SE-29-52-14-4 (old airport road)	630.02 m

Looking d/s HWM VR 83-5 26 June 1983

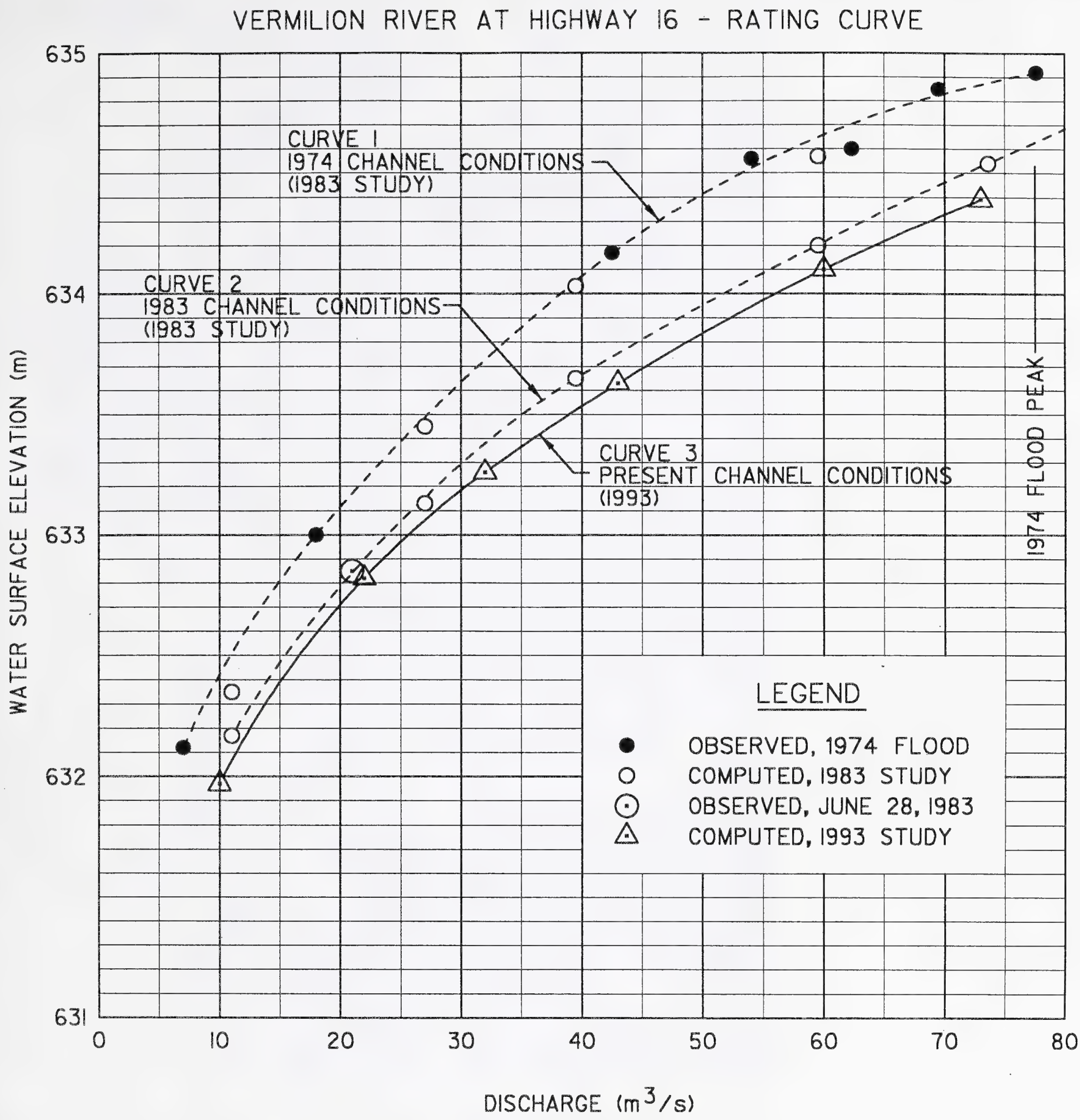
BENCH MARK REFERENCE	LOCATION	ELEVATION
83E-209	SEC-32-52-14-4	631.650 m

Description: Top of piece of metal embedded into cement in NE corner of bridge.

Figure 3.5

Vermilion River 1983 Flood

Old Airport Road Bridge



ALBERTA ENVIRONMENTAL PROTECTION

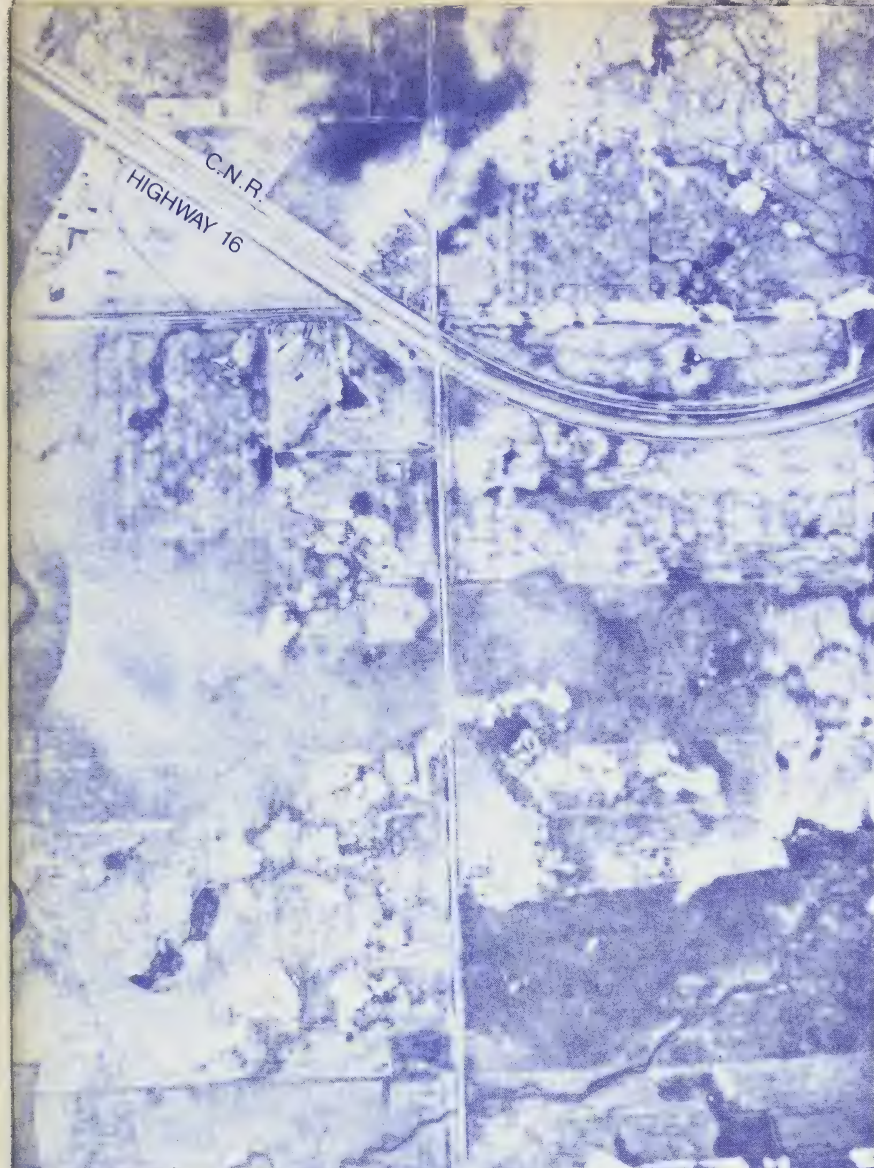
VEGREVILLE FLOOD RISK MAPPING STUDY

VERMILION RIVER AT HIGHWAY No. 16 BRIDGE
RATING CURVES

SNC◆LAVALIN

DECEMBER 1993

FIGURE 3.6



ɾREVILLE FLOOD RISK MAPPING STUDY
FIGURE 3.7
1974 FLOOD PHOTO MOSAIC

SNC·LAVALIN
Edmonton


47 STREET


47 STREET
OLD AIRPORT
ROAD

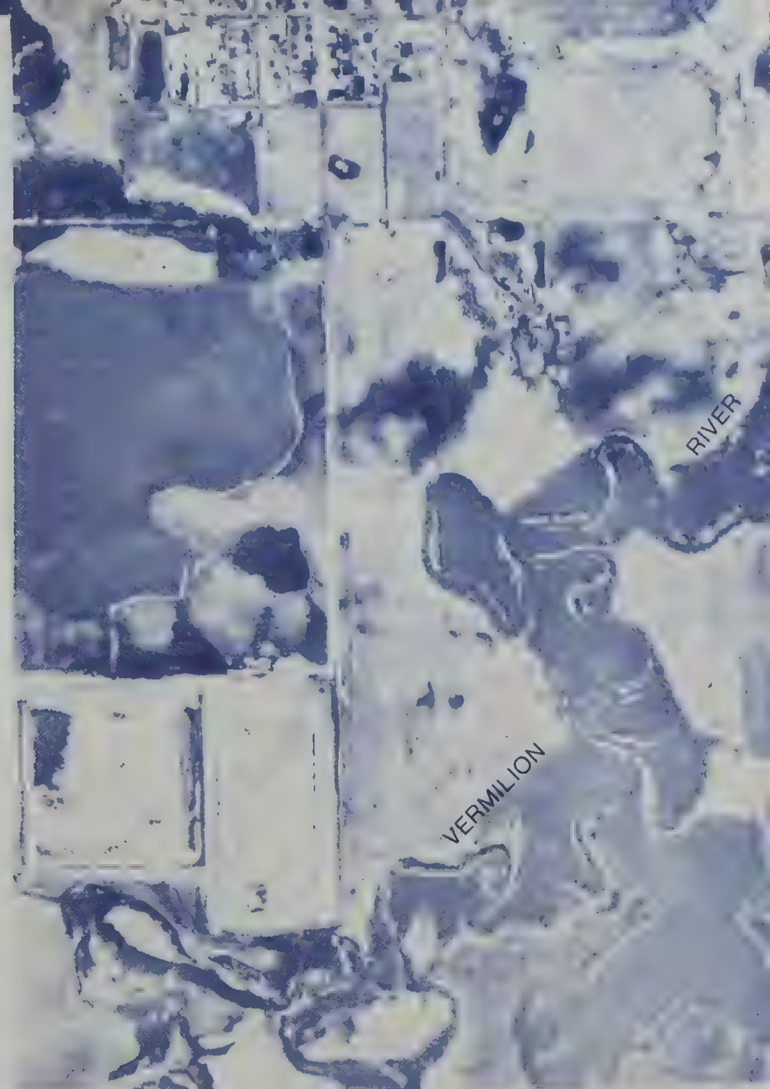
47 STREET
AIRPORT
ROAD
SWALE A
WEST TRIBUTARY
60 STREET
61 AVENUE
NORTH DRAIN
HIGHWAY 16

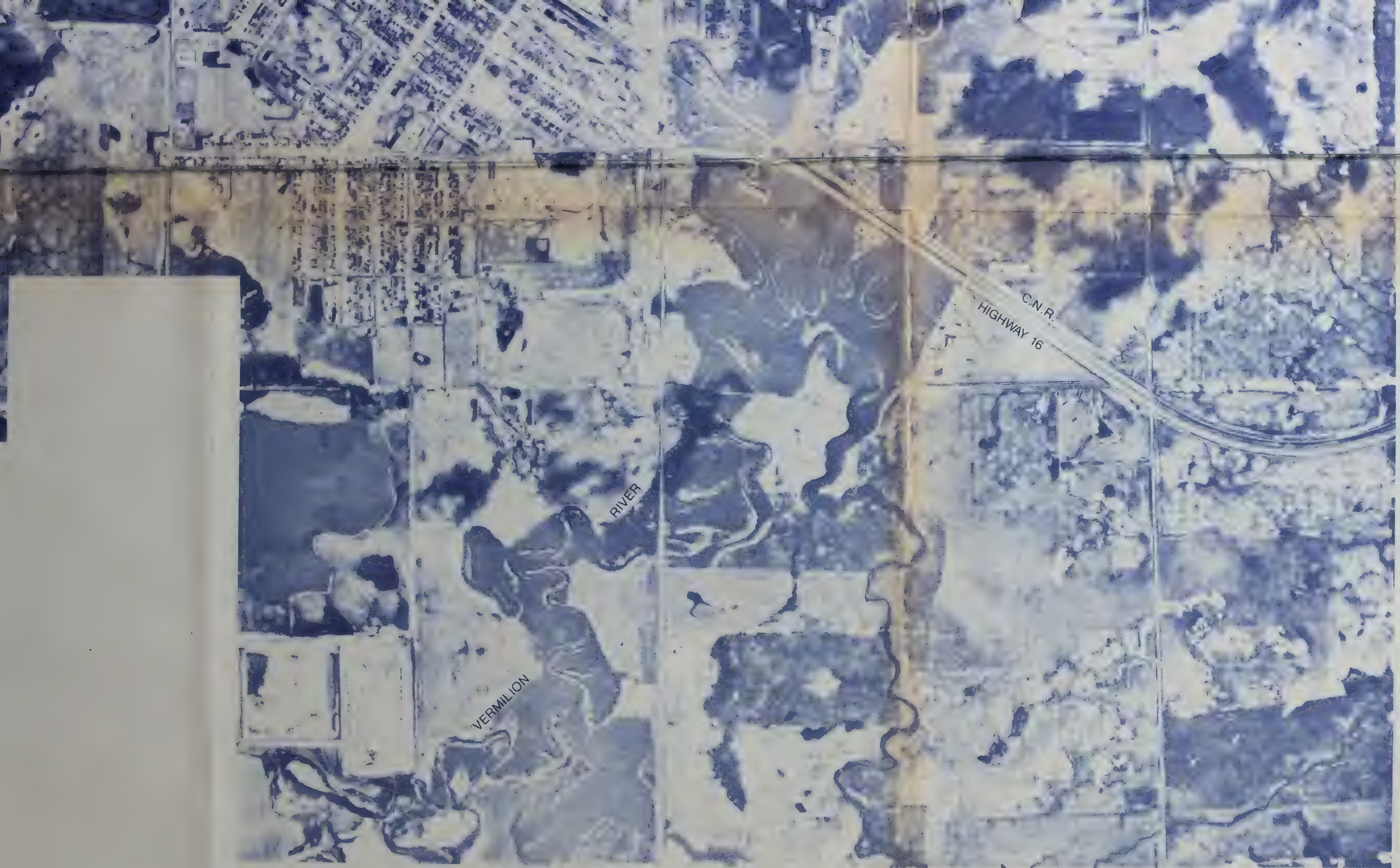
47 STREET
AIRPORT
ROAD
60 STREET
61 AVENUE

PHOTO DATE: APRIL 22, 1974

ROLL: AS 1283

SCALE: 1:12,000





VEGREVILLE FLOOD RISK MAPPING STUDY
FIGURE 3.7
1974 FLOOD PHOTO MOSAIC

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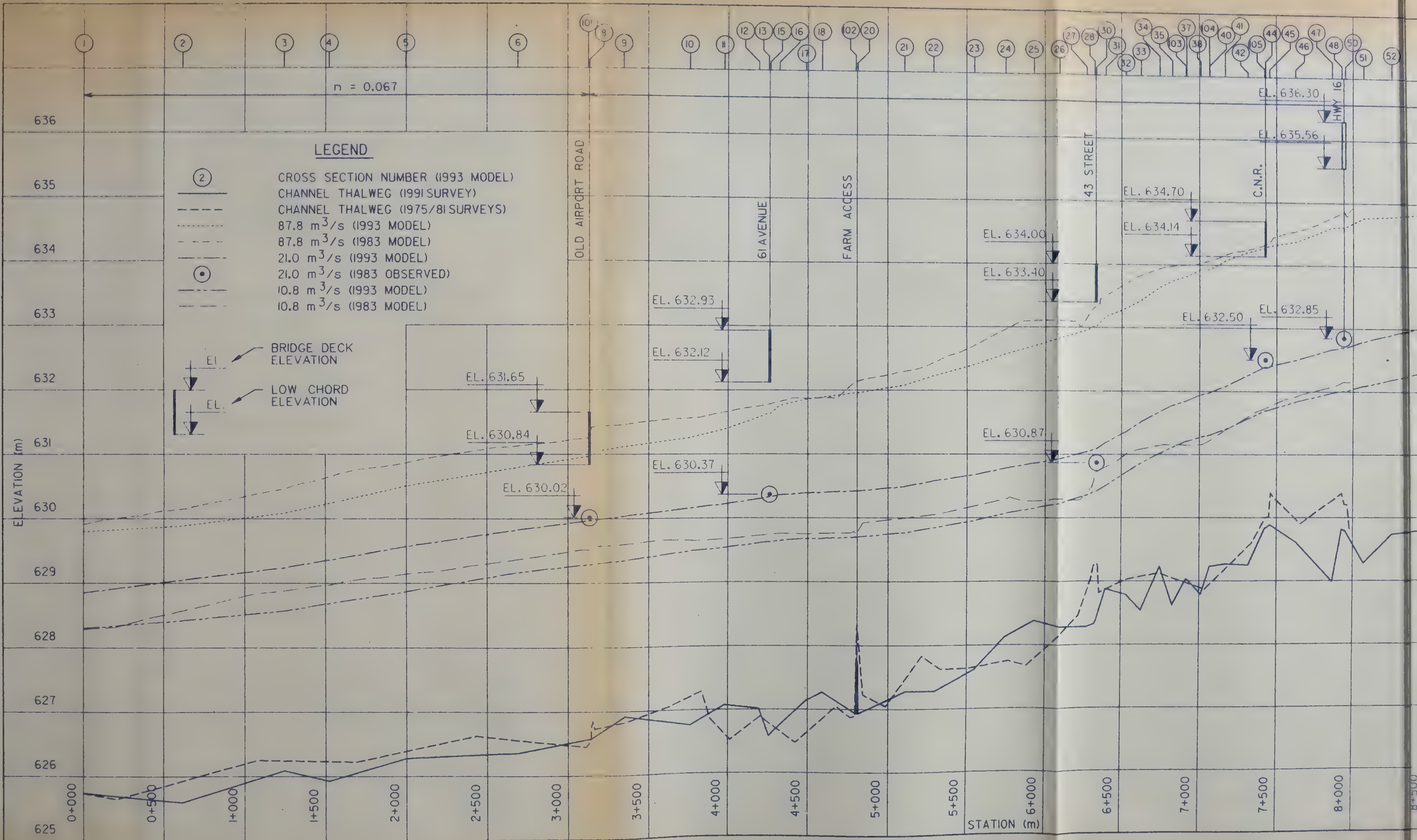
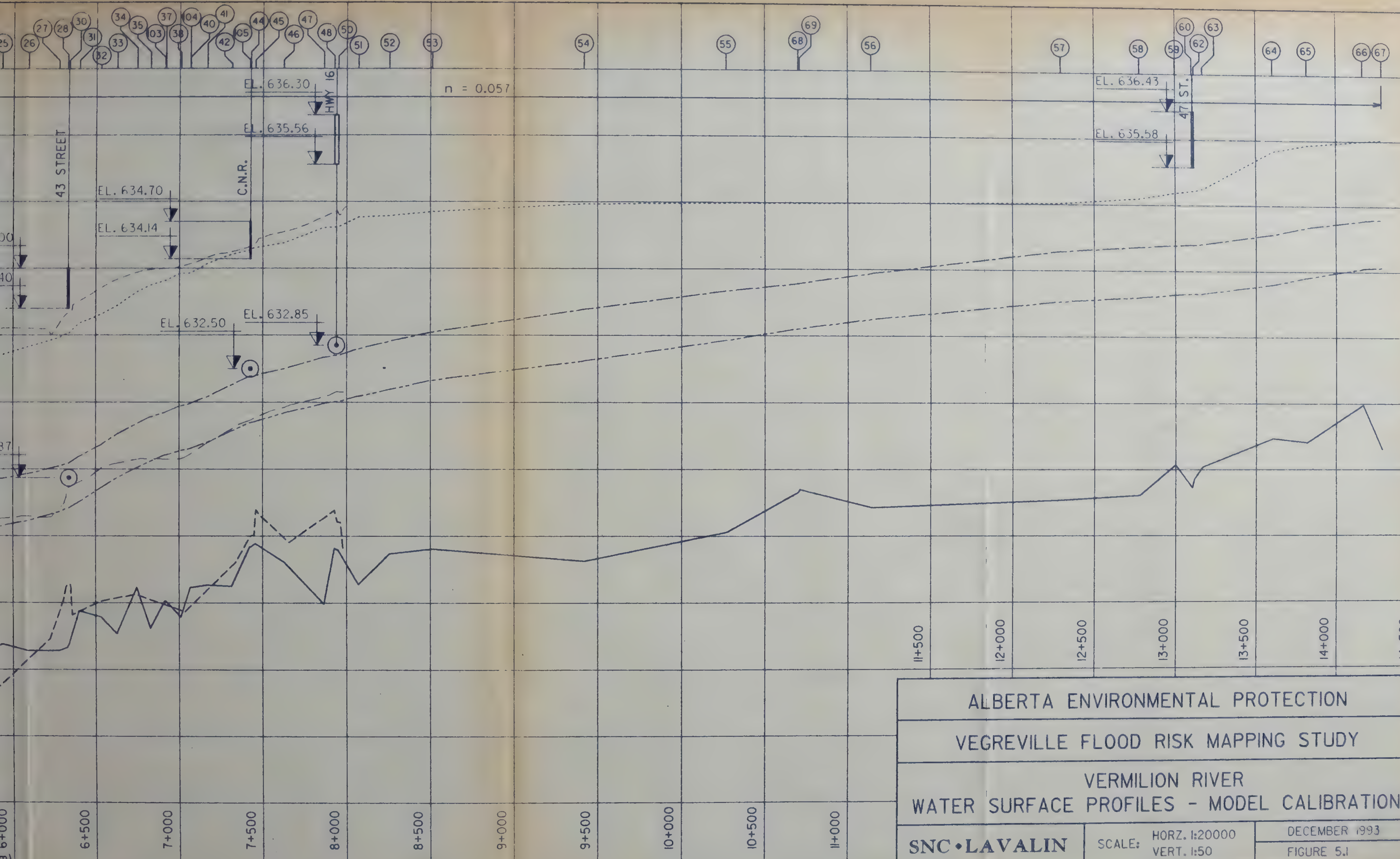
Edmonton



n = 0.067
LEGEND
CROSS SECTION NUMBER (1993 MODEL)
CHANNEL THALWEG (1991 SURVEY)
CHANNEL THALWEG (1975/81 SURVEYS)
87.8 m3/s (1993 MODEL)
87.8 m3/s (1983 MODEL)
21.0 m3/s (1993 MODEL)
21.0 m3/s (1983 OBSERVED)
10.8 m3/s (1993 MODEL)
10.8 m3/s (1983 MODEL)
BRIDGE DECK ELEVATION
LOW CHORD ELEVATION
OLD AIRPORT ROAD
61 AVENUE
FARM ACCESS
43 STREET
C.N.R.
HWY 16
EL. 631.65
EL. 630.84
EL. 630.02
EL. 632.93
EL. 632.12
EL. 630.37
EL. 634.00
EL. 633.40
EL. 630.87
EL. 634.70
EL. 634.14
EL. 636.30
EL. 635.56
EL. 632.50
EL. 632.85
ELEVATION (m)
636
635
634
633
632
631
630
629
628
627
626
625
0+000
0+500
1+000
1+500
2+000
2+500
3+000
3+500
4+000
4+500
5+000
5+500
6+000
6+500
7+000
7+500
8+000
8+500
STATION (m)

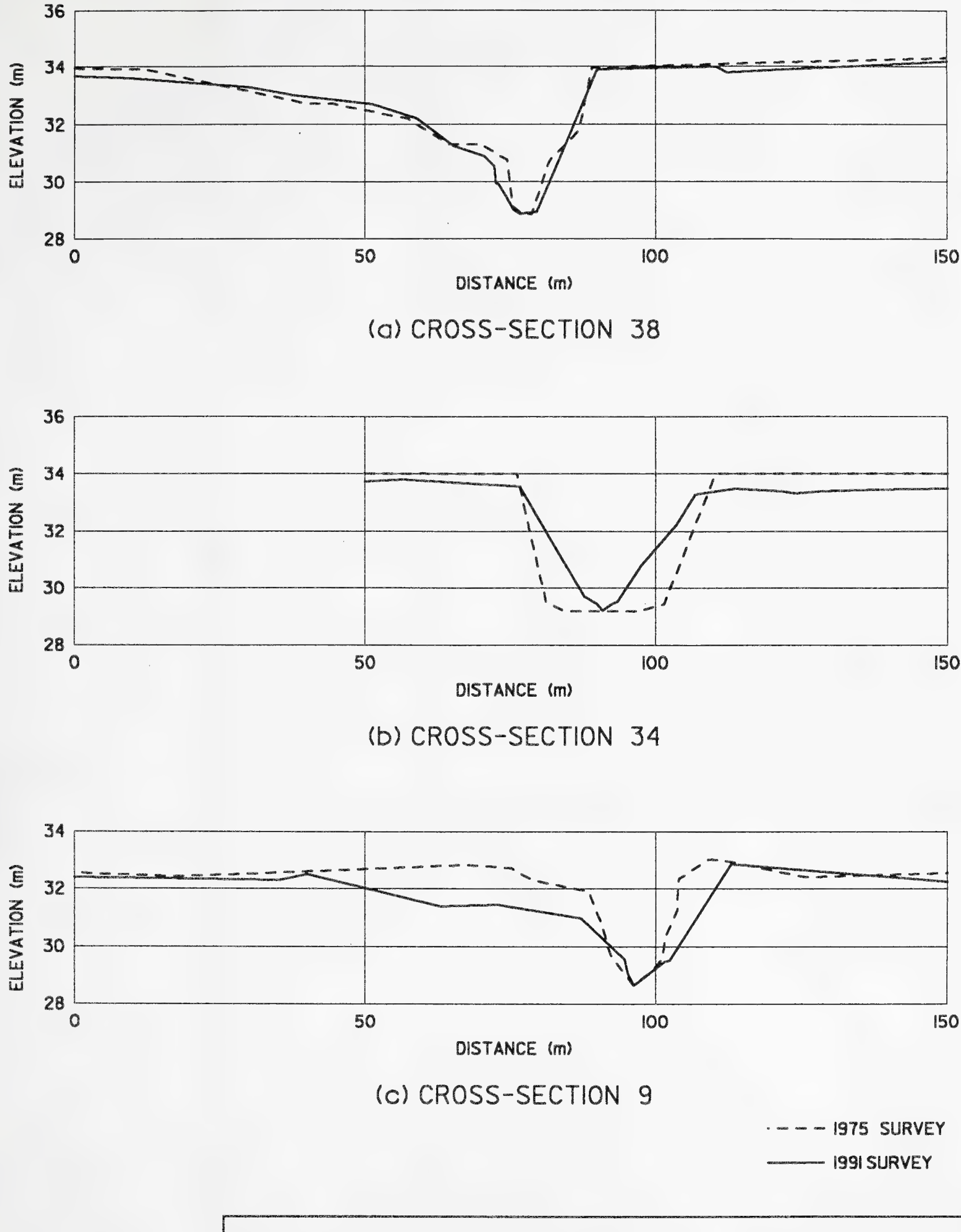


ALBERTA ENVIRONMENTAL PROTECTION

VEGREVILLE FLOOD RISK MAPPING STUDY

VERMILION RIVER
WATER SURFACE PROFILES - MODEL CALIBRATION

SNC • LAVALIN	SCALE:	HORZ. 1:20000 VERT. 1:50	DECEMBER 1993 FIGURE 5.1



ALBERTA ENVIRONMENTAL PROTECTION

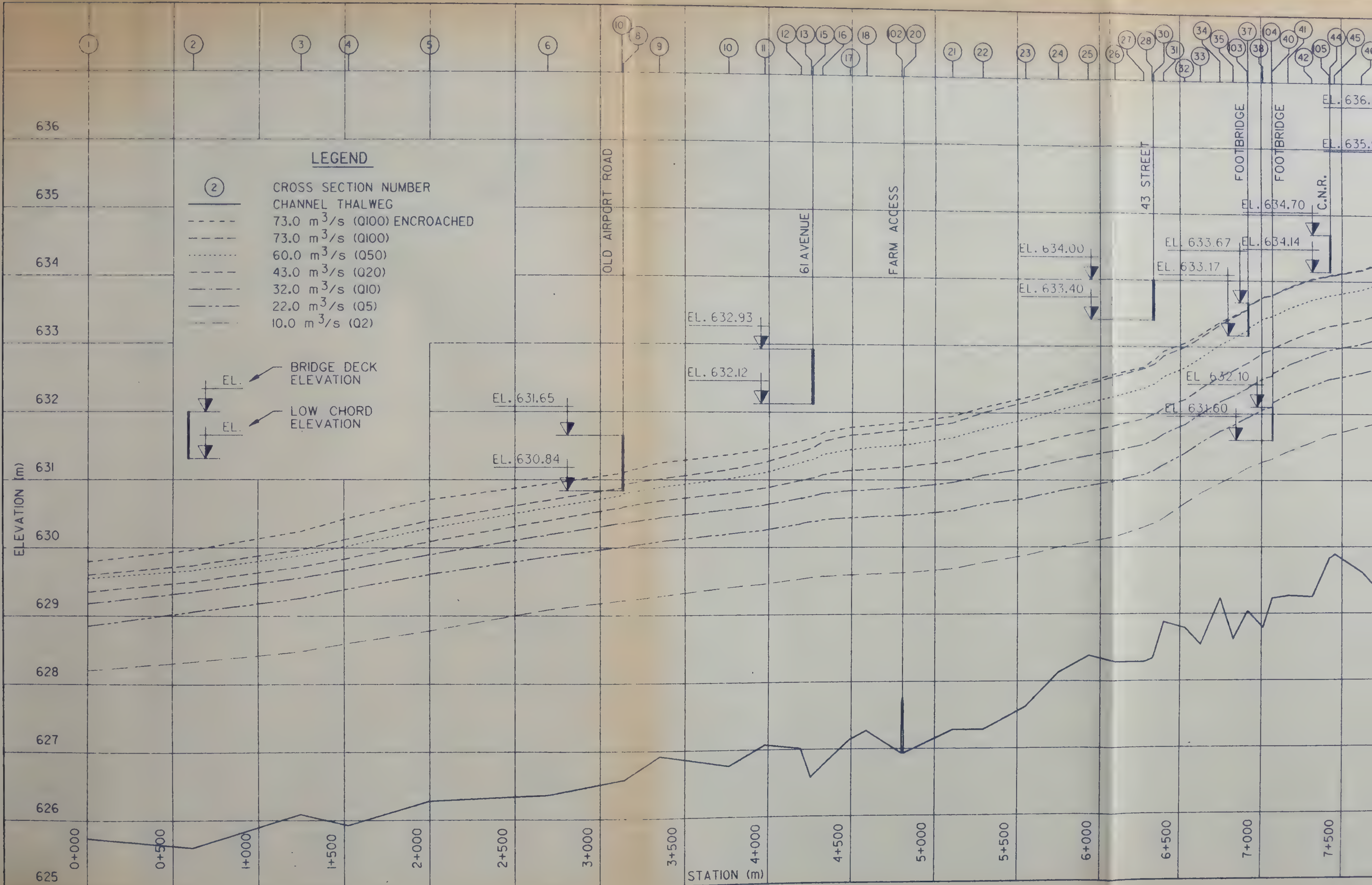
VEGREVILLE FLOOD RISK MAPPING STUDY

VERMILION RIVER
CHANNEL GEOMETRY CHANGES

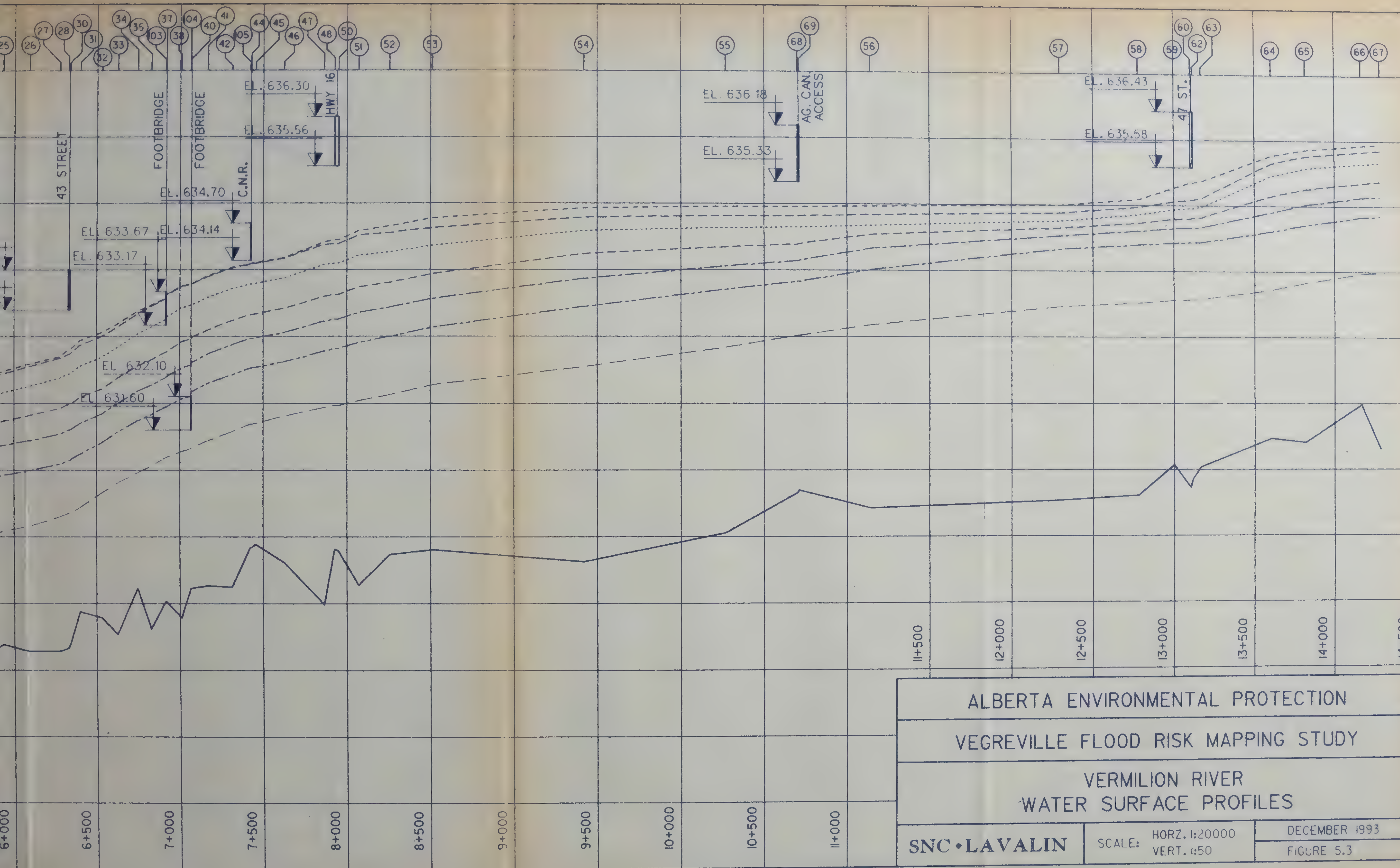
SNC • LAVALIN

DECEMBER 1993

FIGURE 5.2



LEGEND
CROSS SECTION NUMBER
CHANNEL THALWEG
73.0 m3/s (Q100) ENCROACHED
73.0 m3/s (Q100)
60.0 m3/s (Q50)
43.0 m3/s (Q20)
32.0 m3/s (Q10)
22.0 m3/s (Q5)
10.0 m3/s (Q2)
BRIDGE DECK ELEVATION
LOW CHORD ELEVATION
OLD AIRPORT ROAD
61 AVENUE
FARM ACCESS
43 STREET
FOOTBRIDGE
FOOTBRIDGE
C.N.R.
EL. 631.65
EL. 630.84
EL. 632.93
EL. 632.12
EL. 634.00
EL. 633.40
EL. 633.67
EL. 633.17
EL. 634.70
EL. 634.14
EL 632.10
EL 631.60
EL. 636.
EL. 635.
ELEVATION (m)
STATION (m)
0+000
0+500
1+000
1+500
2+000
2+500
3+000
3+500
4+000
4+500
5+000
5+500
6+000
6+500
7+000
7+500

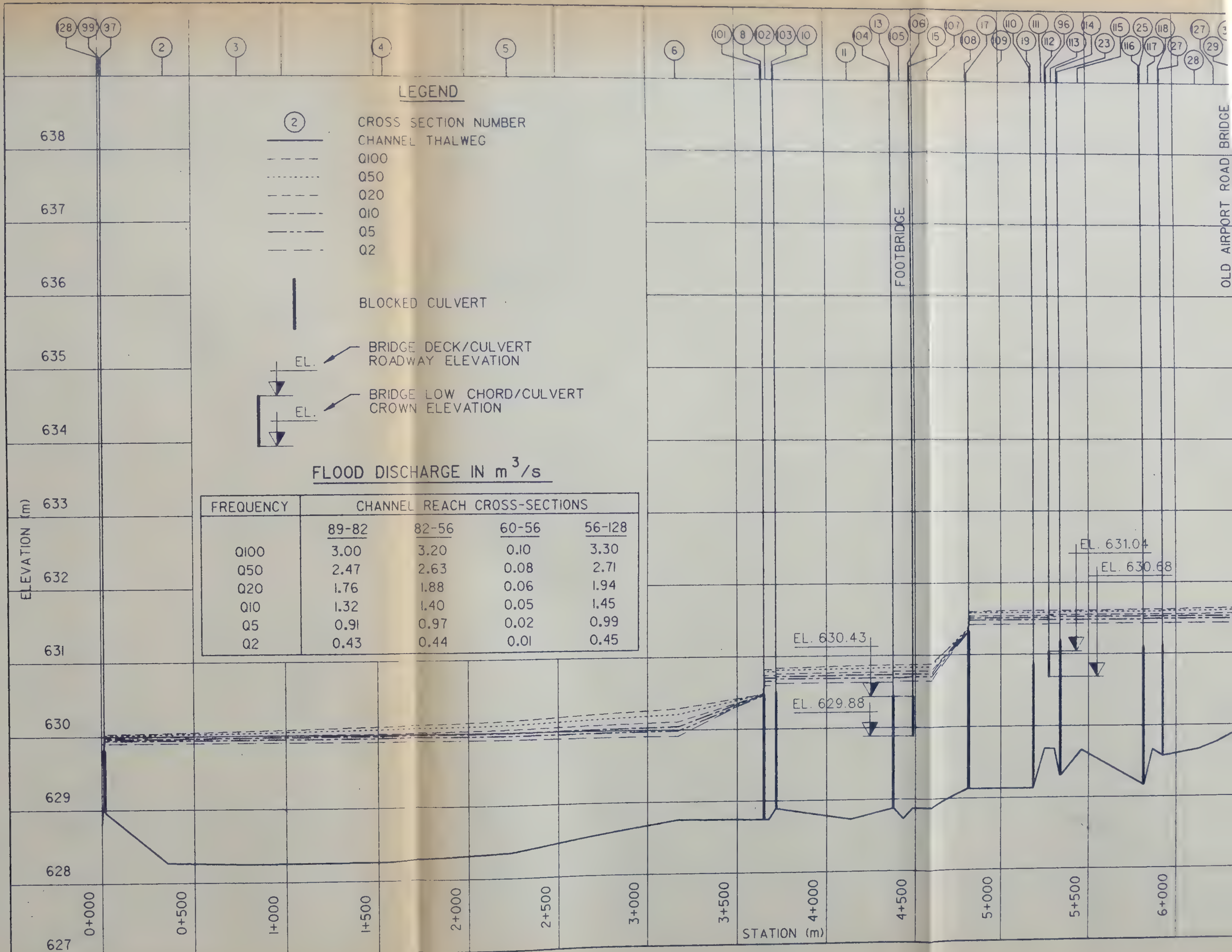


ALBERTA ENVIRONMENTAL PROTECTION

VEGREVILLE FLOOD RISK MAPPING STUDY

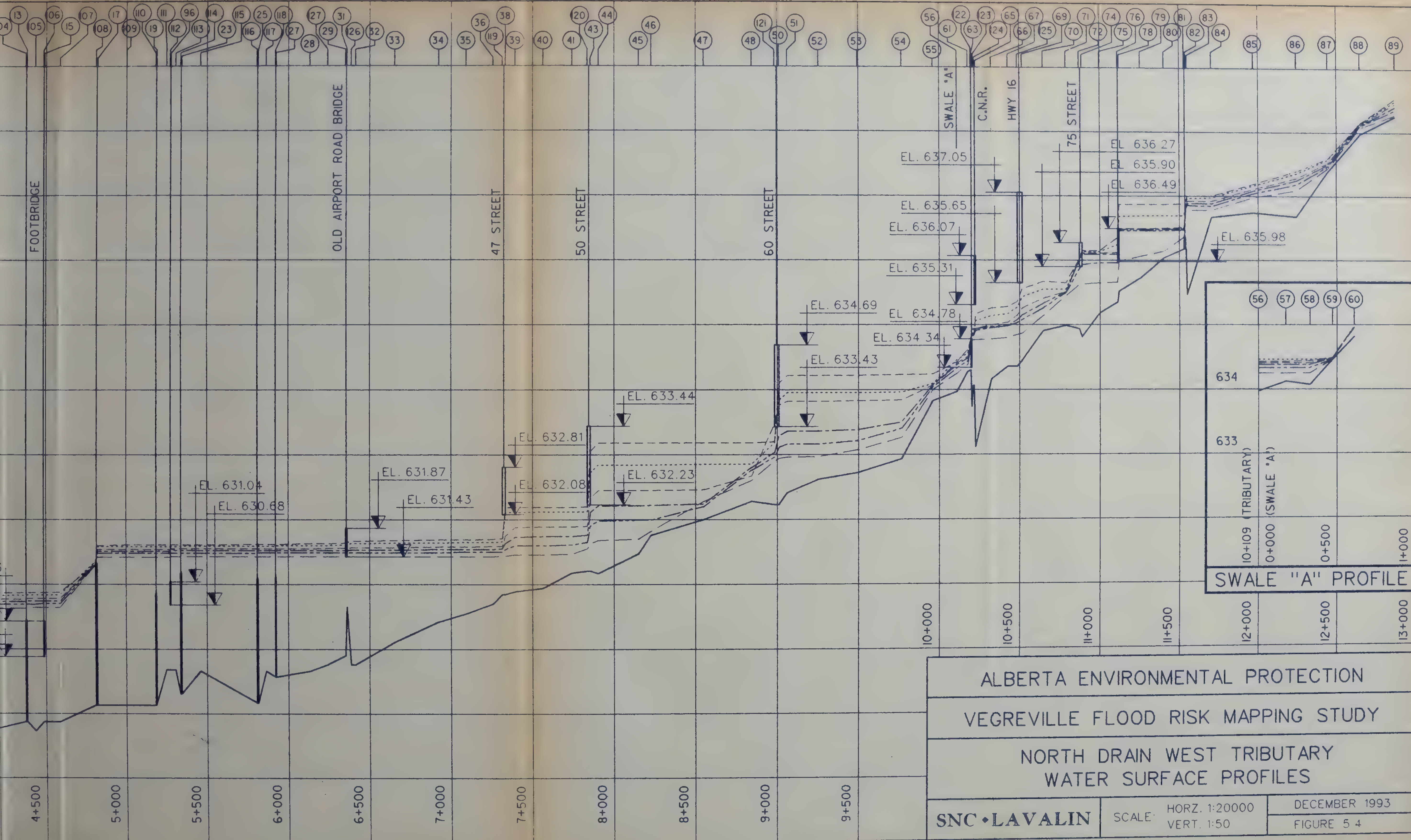
VERMILION RIVER
WATER SURFACE PROFILES

SNC•LAVALIN	SCALE:	HORZ. 1:20000 VERT. 1:50	DECEMBER 1993 FIGURE 5.3



FLOOD DISCHARGE IN m^3/s

FREQUENCY	CHANNEL REACH CROSS-SECTIONS			
	89-82	82-56	60-56	56-128
Q100	3.00	3.20	0.10	3.30
Q50	2.47	2.63	0.08	2.71
Q20	1.76	1.88	0.06	1.94
Q10	1.32	1.40	0.05	1.45
Q5	0.91	0.97	0.02	0.99
Q2	0.43	0.44	0.01	0.45

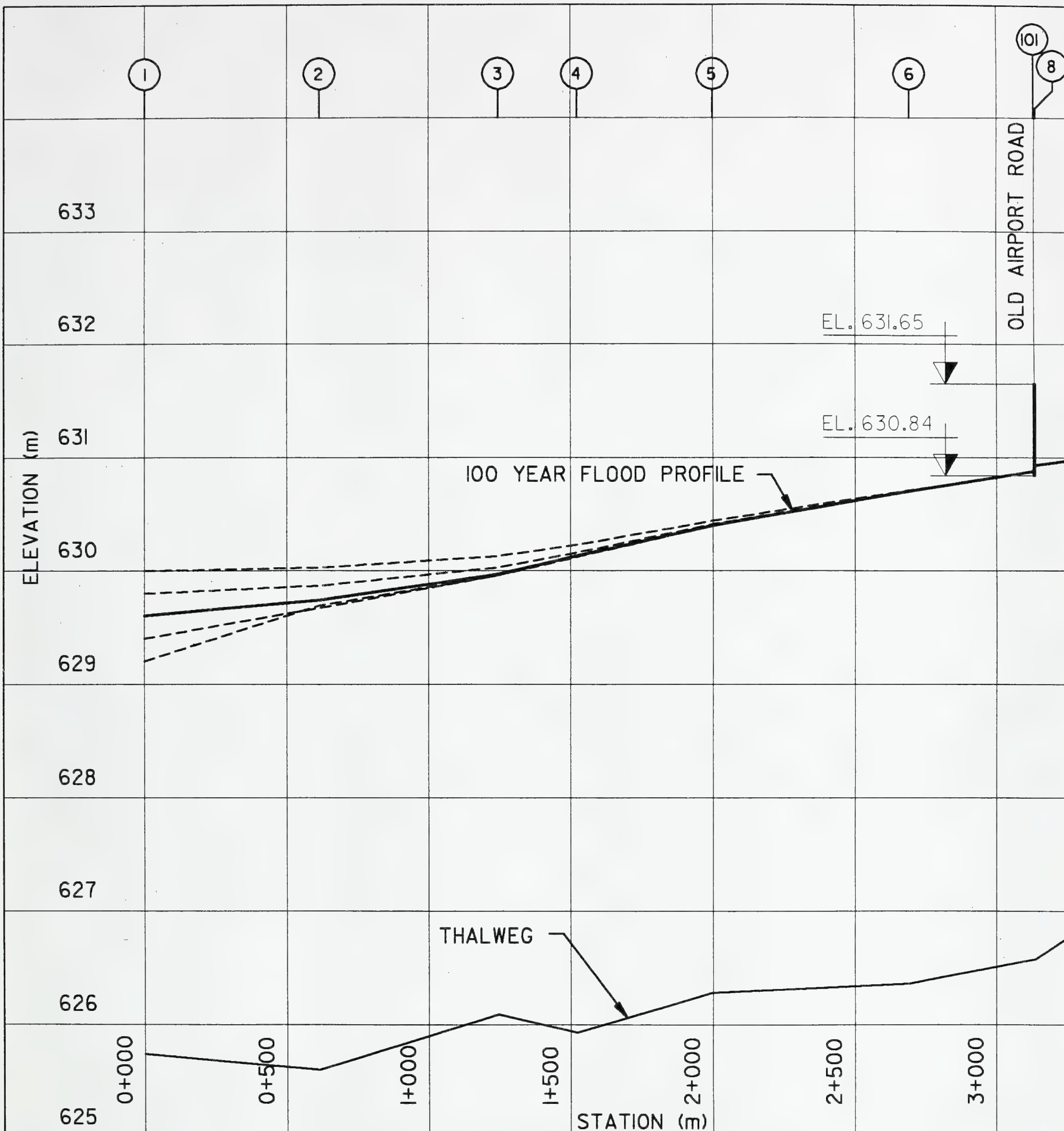


ALBERTA ENVIRONMENTAL PROTECTION

VEGREVILLE FLOOD RISK MAPPING STUDY

NORTH DRAIN WEST TRIBUTARY
WATER SURFACE PROFILES

SNC ◆ LAVALIN	SCALE:	HORZ. 1:20000 VERT. 1:50	DECEMBER 1993 FIGURE 5.4



ALBERTA ENVIRONMENTAL PROTECTION

VEGREVILLE FLOOD RISK MAPPING STUDY

VERMILION RIVER - 100 YEAR FLOOD PROFILE
SENSITIVITY TO STARTING WATER LEVEL

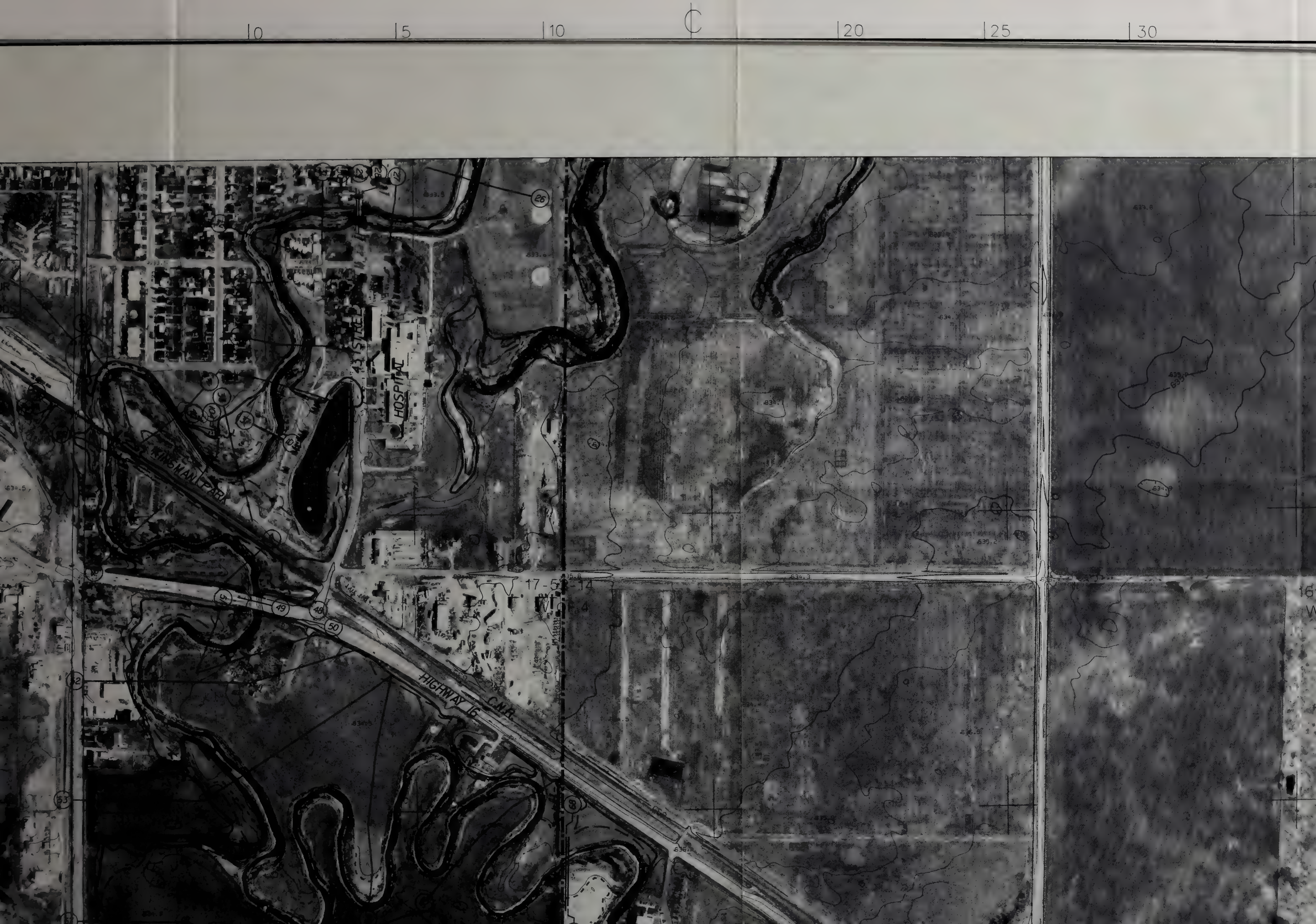
SNC • LAVALIN

DECEMBER 1993

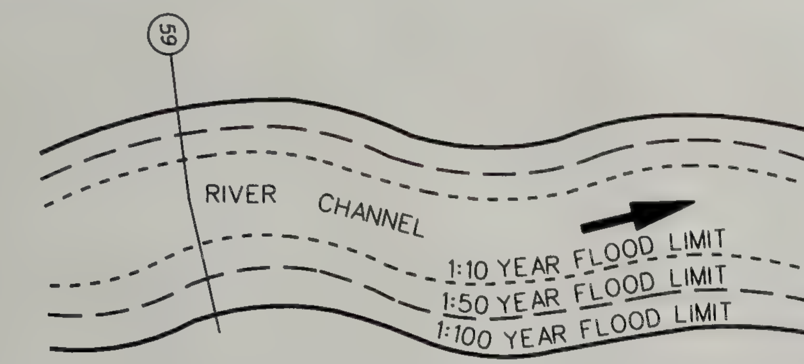
FIGURE 5.5

MAPS


SPILL MAY OCCUR
INTO AND SWALES
1:50 AND HIGHER FLOODS
KINSMAN PARK
636.5
637.7


0
5
10
20
25
30
43 STREET
HOSPITAL
KINSMAN PARK
HIGHWAY 16
C.N.R.
17-53-14
W4

LEGEND



59 CROSS-SECTION NUMBER AND LOCATION (ORIENTED FACING DOWNSTREAM)

TOWN BOUNDARY

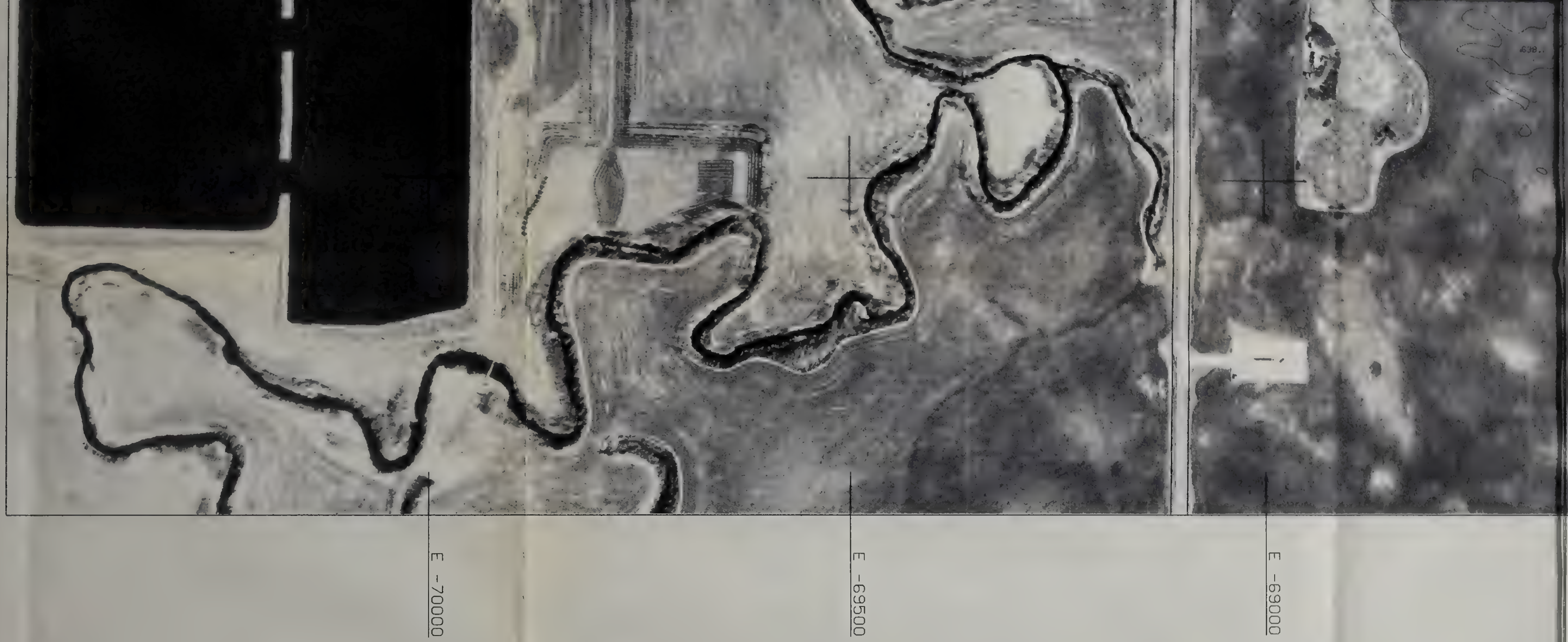
FLOW DIRECTION

H HIGHER GROUND ABOVE FLOOD LIMITS


TOWN OF VEGREVILLE
COUNTY OF MINBURN
41 STREET
VERMILION
RIVER
HIGHWAY 16 BYPASS
WATER SUPPLY RESERVOIRS
7-52-14
W. OF 4


CANADA
AGRICULTURE
HIGHWAY 16 BYPASS
8-52-14
W. OF 4
9-52-14
W. OF 4

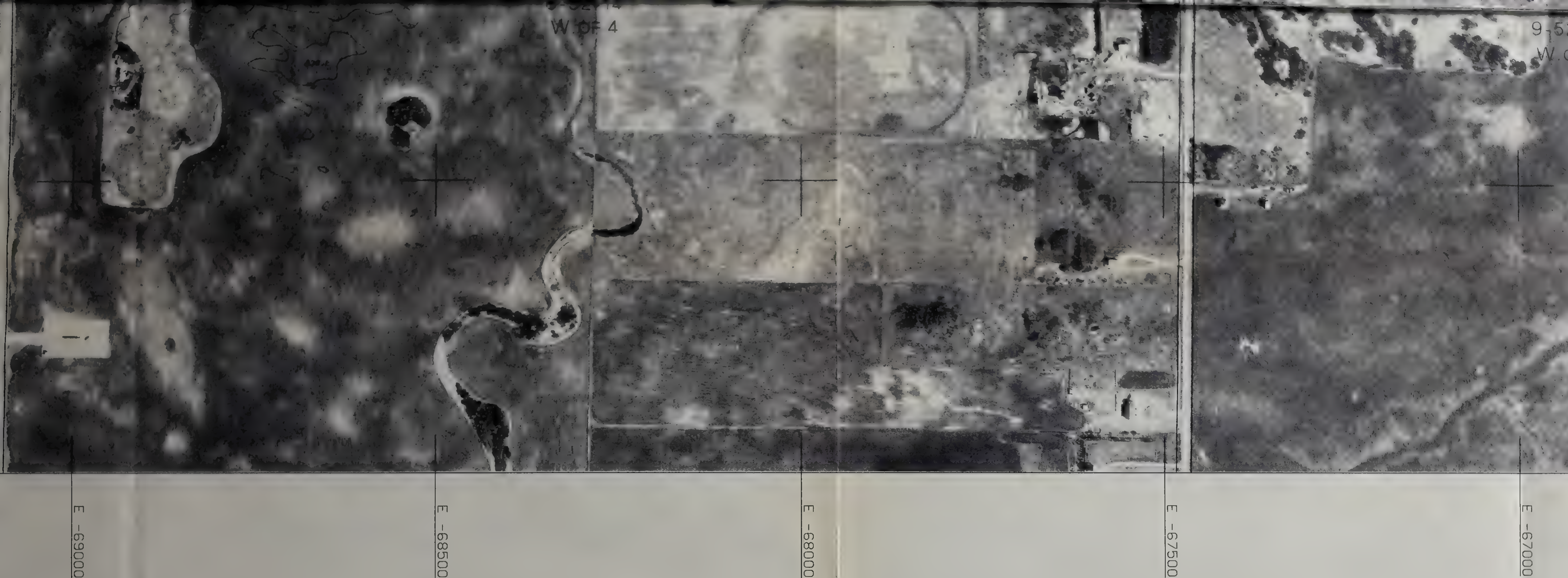
SCALE 1 : 5 000

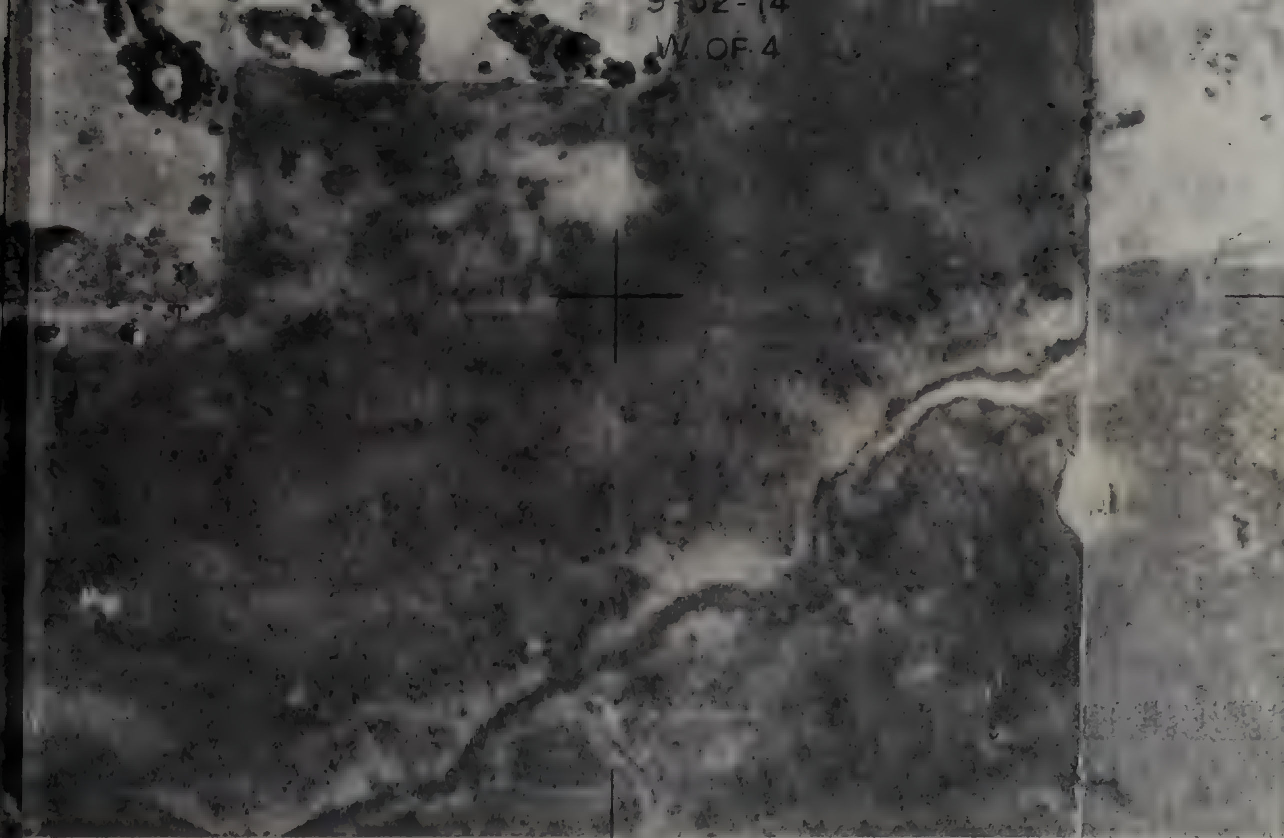


Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Environment Canada | Environnement Canada

Alberta
ENVIRONMENTAL PROTECTION


W. OF 4
9-52
E -69000
E -68500
E -68000
E -67500
E -67000



SCALE 1 : 5 000

Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: in metres above mean sea level, North American Datum, 1927

1.0 metre contour

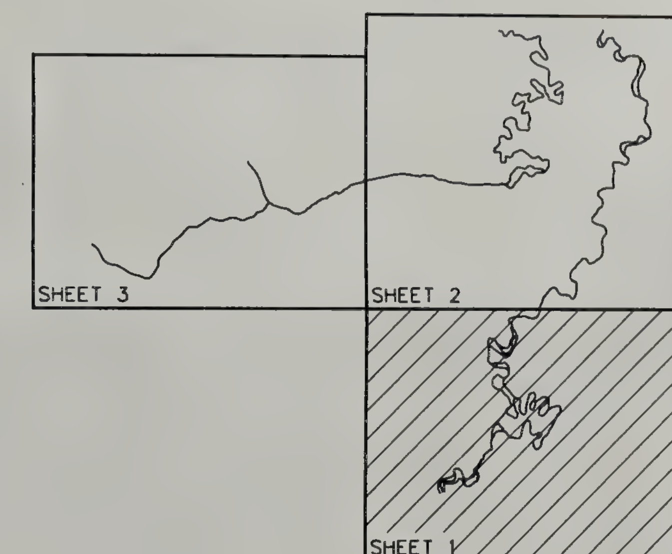
1.0 metre index contour

Depression contour

Spot height in metres

Orthophoto MAY 1991

Contours MAY 1991



SHEET INDEX

SNC·LAVALIN

PROJECT:
VEGREVILLE FLOOD RISK MAPPING STUDY

DRAWING TITLE
FLOOD FREQUENCY MAP
SHEET 1

JOB No

ACCOUNT No

CLIENT DRAWING No

REV

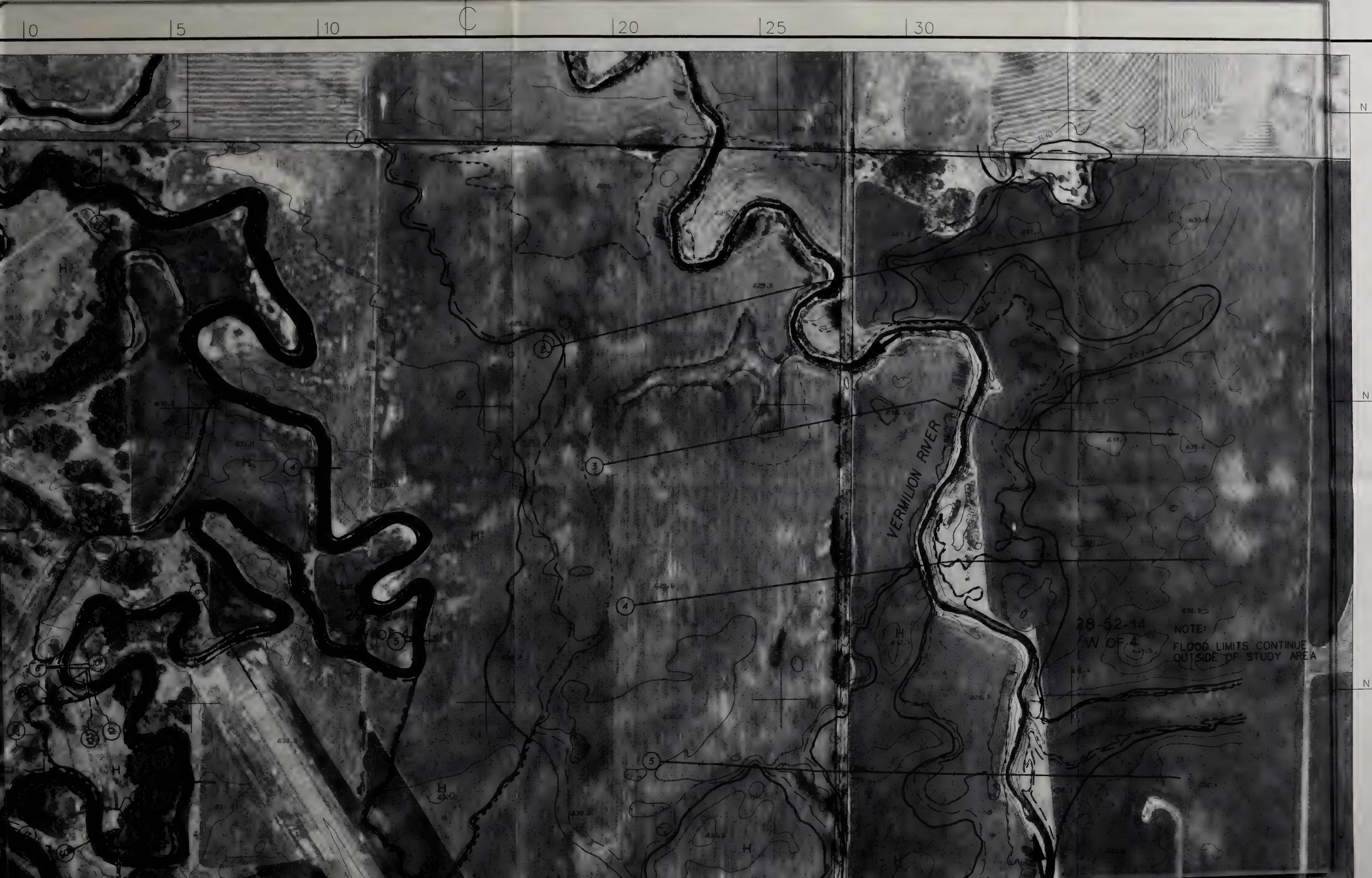
SCALE
1:5000

DRAWING No
6005-101

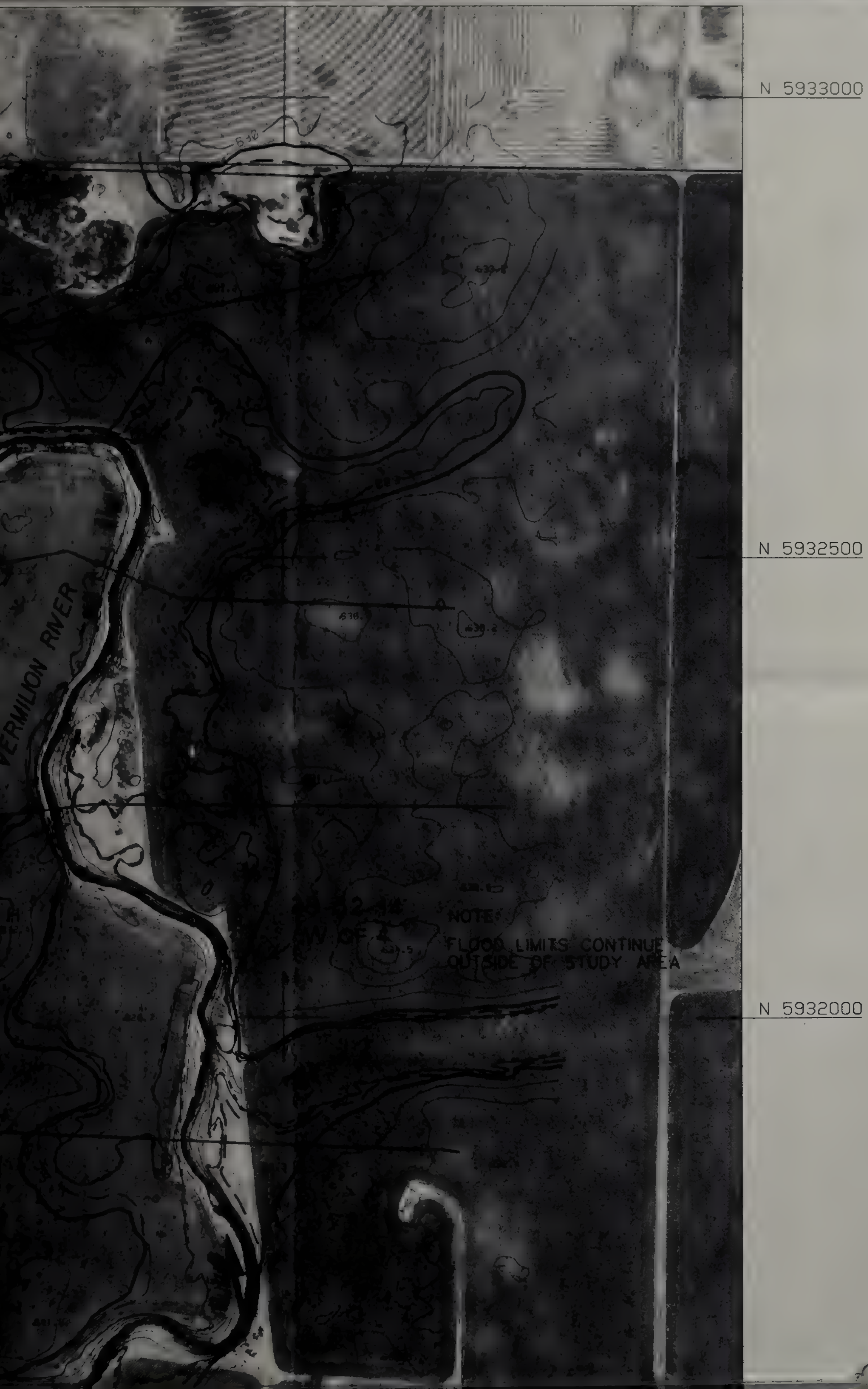
REV

Filename : 600500AB.DGN

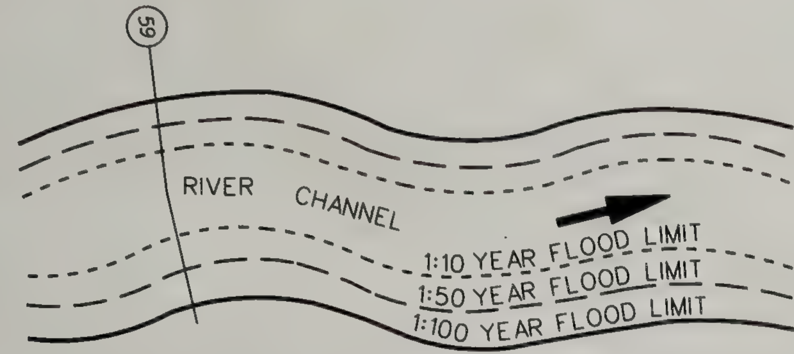

NOTE:
NORTH DRAIN WEST TRIBUTARY IS BLOCKED AT 47 STREET; OVERBANK FLOW OCCURS AT SECTION 99 AS SHOWN
NOTE:
SPILL OVER ROADWAY MAY OCCUR INTO DITCHES AND SWALES FOR 1:50 AND HIGHER FLOODS
0-52-14
W OF 4
47 STREET
GOLF COURSE



0
5
10
20
25
30
VERMILION RIVER
28-52-14
W. OF 4
NOTE:
FLOOD LIMITS CONTINUE
OUTSIDE OF STUDY AREA



LEGEND



(59) CROSS-SECTION NUMBER AND LOCATION (ORIENTED FACING DOWNSTREAM)

TOWN BOUNDARY

FLOW DIRECTION

H HIGHER GROUND ABOVE FLOOD LIMITS

NOTE - VEGREVILLE AIRPORT AREA FLOODING

IN THE VEGREVILLE AIRPORT AREA OVERBANK FLOODING FROM THE NORTH DRAIN WEST TRIBUTARY (NDWT), WILL TEND TO BE AT A HIGHER ELEVATION THAN OVERBANK FLOODING FROM THE VERMILION RIVER. THIS WILL TEND TO CAUSE FLOOD WATERS TO FLOW FROM THE NDWT TO THE VERMILION RIVER. IN THAT SITUATION THE VERMILION RIVER LEFT OVERBANK FLOOD LIMITS WILL BE SUPERSEDED BY THE FLOW COMING FROM THE NDWT. NEVERTHELESS THE VERMILION RIVER LEFT OVERBANK FLOOD LIMITS HAVE BEEN RETAINED ON THIS MAP, BUT AS LIGHTER LINES.


COUNTY OF MINBURN
OLD AIRPORT ROAD
TOWN OF VEGREVILLE
NORTH DRAIN
WEST TRIBUTARY
50 STREET

COUNTY OF MINBURN
OLD AIRPORT ROAD
TOWN OF VEGREVILLE
WEST TRIBUTARY
VEGREVILLE AIRPORT
OLD AIRPORT ROAD
61 AVENUE
50 STREET

N 5931500
NOTE:
FLOOD LIMITS CONTINUE OUTSIDE OF STUDY AREA
N 5931000
632.1
635

SCALE 1:5 000

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

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Environnement Canada

Alberta
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61 AVENUE
47 STREET
52-14
OF 4
VERMILION
RIVER
CEMETERY
E -69000
E -68500
E -68000
E -67500

N 5930500

N 5930000

E 67000

SCALE 1 : 5 000

metres 0 100 200 300 400 500 600 metres

feet 0 100 500 1,000 1,500 2,000 feet

Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: in metres above mean sea level, North American Datum, 1927

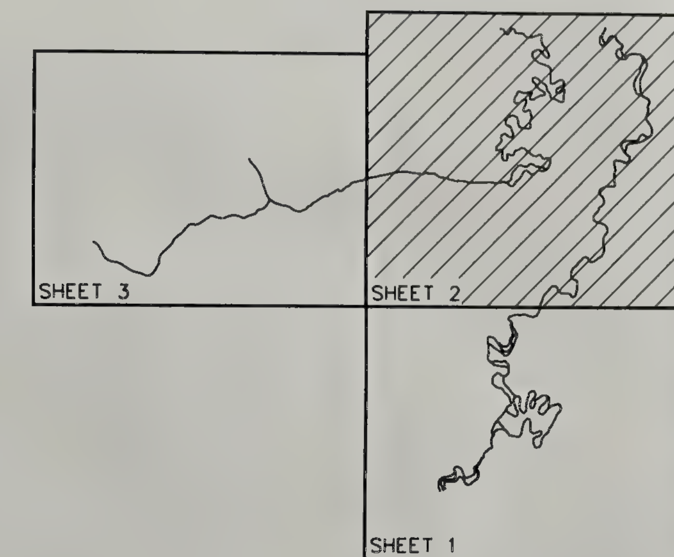
1.0 metre contour

1.0 metre index contour

Depression contour

.1082.5 Spot height in metres

Orthophoto	MAY 1991
Contours	MAY 1991



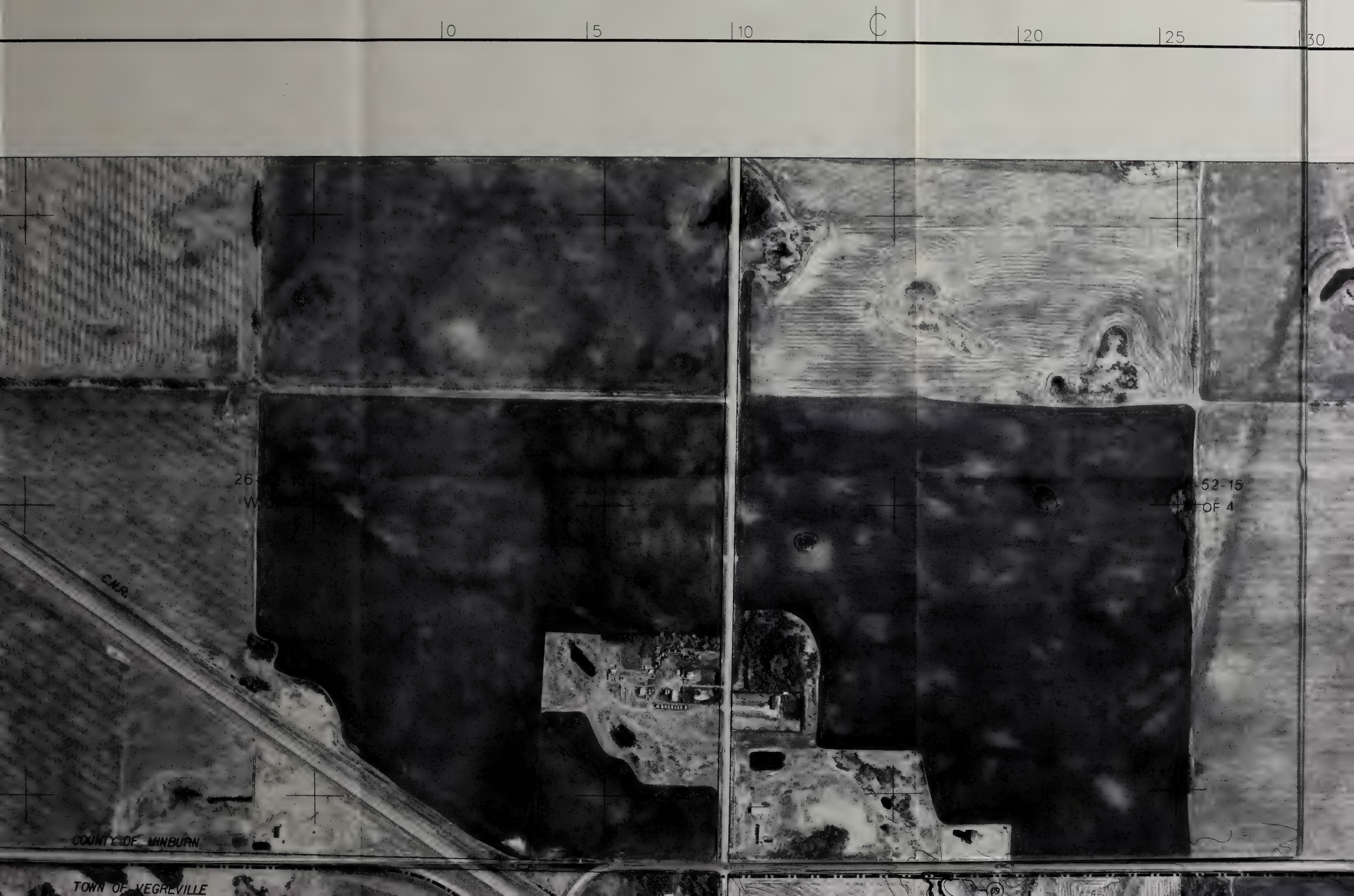
SHEET INDEX

SNC·LAVALIN

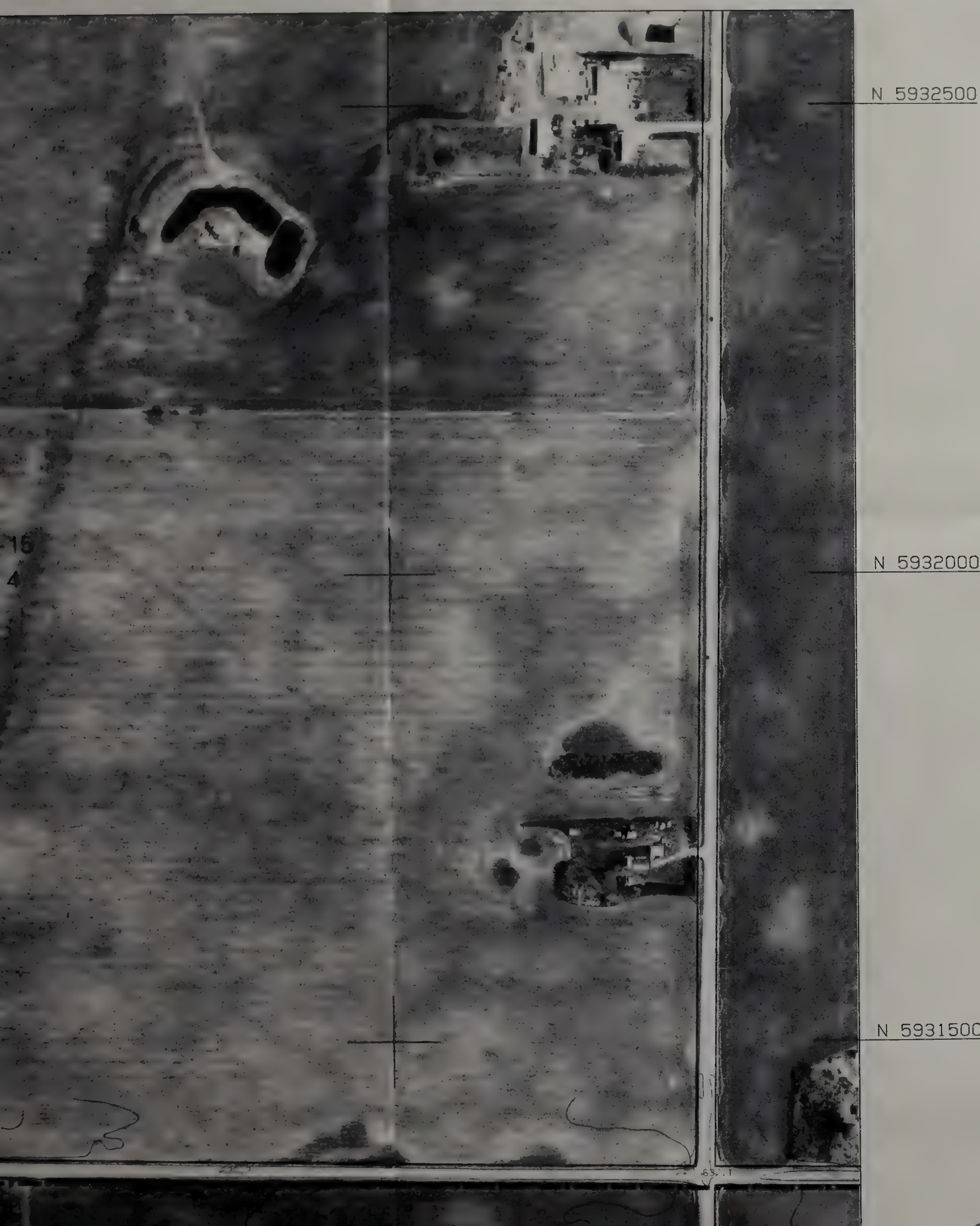
PROJECT: VEGREVILLE FLOOD RISK MAPPING STUDY		
DRAWING TITLE: FLOOD FREQUENCY MAP SHEET 2		JOB No
		ACCOUNT No
CLIENT DRAWING No	REV	SCALE 1:5000
DRAWING No 6005-102		REV

Filename : 600500AC.DGN

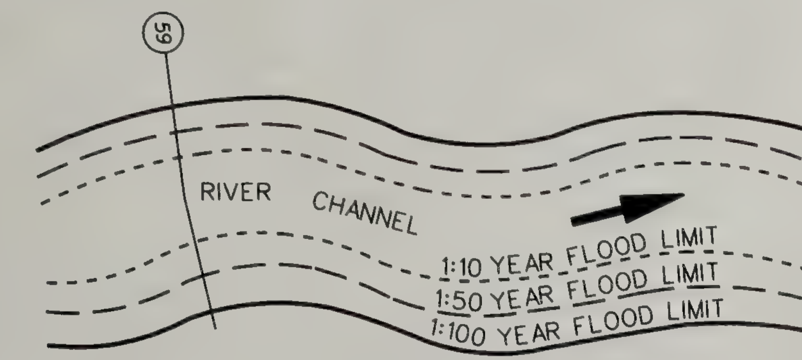
27-52-15
W.OF 4
26-52-15
W.OF 4
C.N.R.
COUNTY OF MINBURN


0
5
10
20
25
30
52-15
OF 4
C.N.R.
COUNTY OF MINBURN
TOWN OF VEGREVILLE

30



LEGEND



(59) CROSS-SECTION NUMBER AND LOCATION (ORIENTED FACING DOWNSTREAM)

TOWN BOUNDARY

FLOW DIRECTION

H HIGHER GROUND ABOVE FLOOD LIMITS


COUNTY OF MINBURN
TOWN OF VEGREVILLE
22-52-15
W.OF 4
23-52-15
W.OF 4
HIGHWAY 16 BYPASS
H

SWALE 'A'
NORTH DRAIN
WEST TRIBUTARY
C.N.R.
HIGHWAY 16
60 STREET
STREET
ALBERTA ENVIRONMENTAL CENTER
24-5
W OF 4

SCALE 1 : 5 000

metres 0 100 200 300 400 500 600 metres

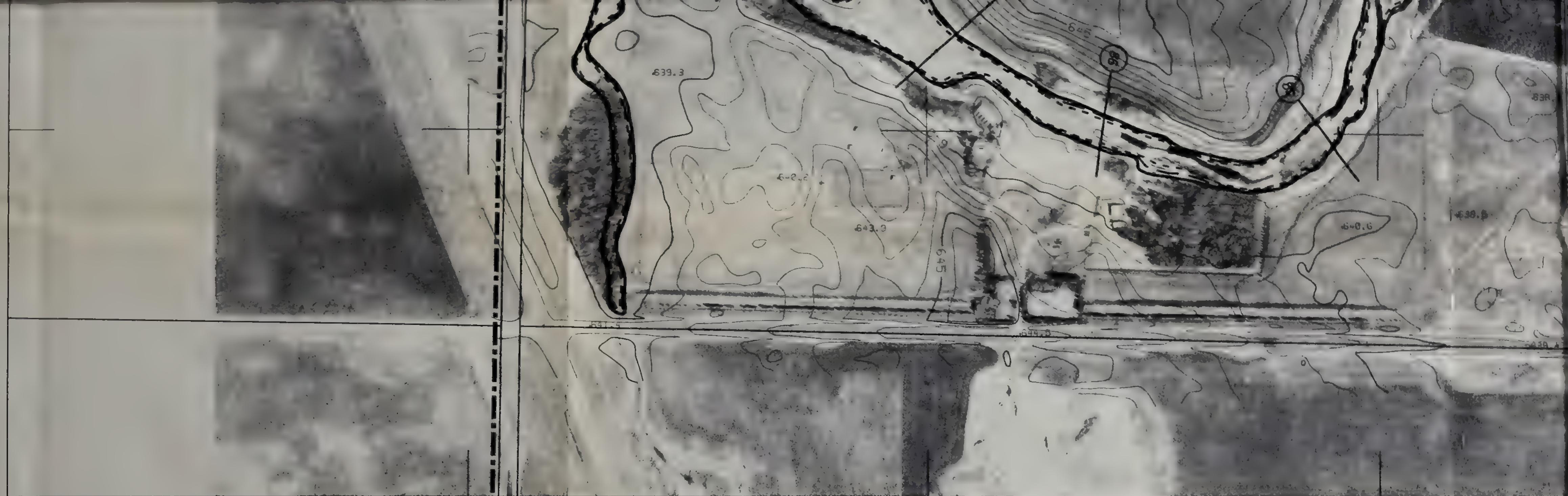
feet 0 100 500 1,000 1,500 2,000 feet

Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: in metres above mean sea level, North American Datum, 1927



E -74000

E -73500

E -73000

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FLOOD
DAMAGE
REDUCTION
PROGRAM

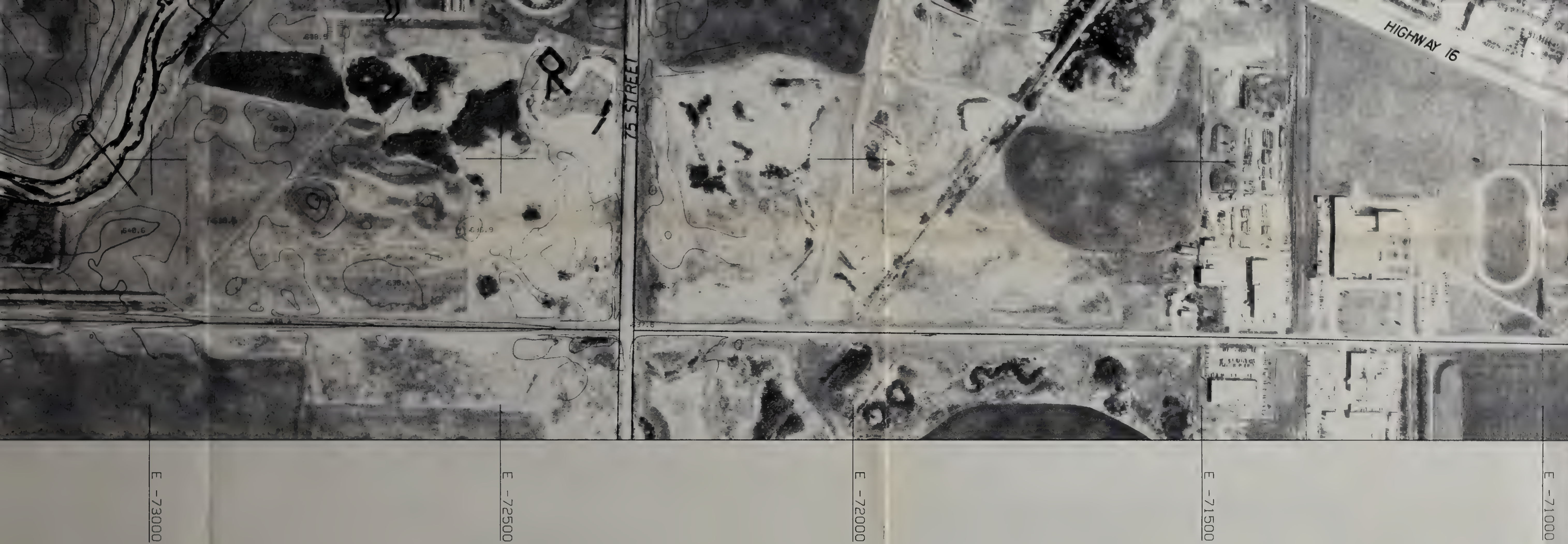
Environment Canada

Environnement Canada

Alberta
ENVIRONMENTAL PROTECTION

February 1993 SNCSTDTB

A0 1189 x 841


HIGHWAY 16
75 STREET
R
E -73000
E -72500
E -72000
E -71500
E -71000

SCALE 1 : 5 000

metres 0 100 200 300 400 500 600 metres
feet 0 100 500 1,000 1,500 2,000 feet

Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour Interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: in metres above mean sea level, North American Datum, 1927

1.0 metre contour

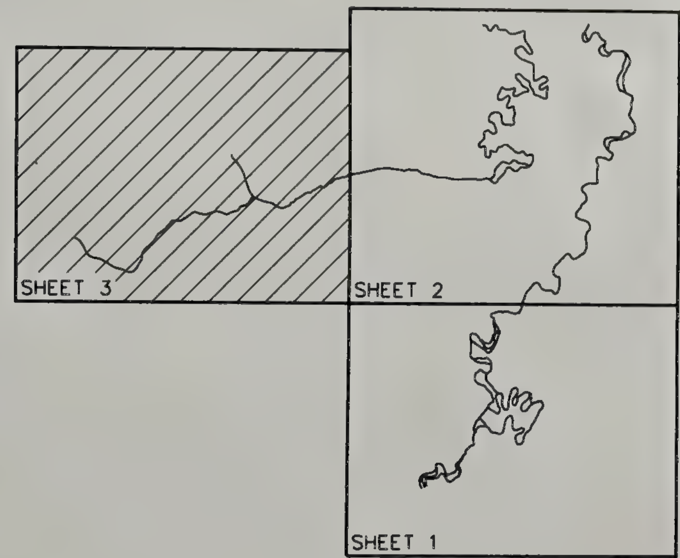
1.0 metre index contour

Depression contour

.1082.6 Spot height in metres

Orthophoto MAY 1991

Contours MAY 1991



SHEET INDEX

SNC·LAVALIN

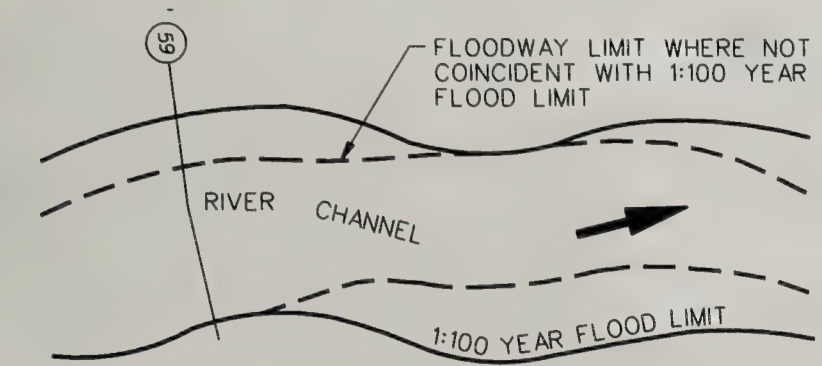
PROJECT: VEGREVILLE FLOOD RISK MAPPING STUDY		
DRAWING TITLE: FLOOD FREQUENCY MAP SHEET 3		JOB No
		ACCOUNT No
CLIENT DRAWING No	REV	SCALE 1:5000
DRAWING No 6005-103		REV

Filename : 600500AD.DGN


NOTE:
OVERBANK SPILL MAY OCCUR
INTO DITCHES AND SWALES.
FOR 1:50 AND HIGHER FLOODS
KINSMAN PARK
634.5
636.5


0
5
10
20
25
30
HIGHWAY 16
C.N.R.
17-52-14

LEGEND



59 CROSS-SECTION NUMBER AND LOCATION (ORIENTED FACING DOWNSTREAM)

TOWN BOUNDARY

FLOW DIRECTION

H HIGHER GROUND ABOVE FLOOD LIMITS

WATER SURFACE ELEVATION IN METRES, FOR 1:100 YEAR FLOOD WITH FLOODWAY ENCROACHMENTS

CROSS-SECTION NUMBER	ELEVATION
26	632.59
27	632.70
28	632.80
29	632.80
30	632.80
31	632.94
32	633.06
33	633.19
34	633.38
35	633.48
103	633.60
37	633.64
38	633.77
104	633.80
40	633.80
41	633.92
42	634.05
105	634.10
44	634.11
45	634.11
46	634.19
47	634.42

CROSS-SECTION NUMBER	ELEVATION
48	634.46
49	634.46
50	634.46
51	634.59
52	634.66
53	634.78
54	634.94
55	634.96
68	634.96
69	634.96
56	634.97
57	635.00
58	635.09
59	635.27
60	635.35
61	635.35
62	635.35
63	635.37
64	635.77
65	635.86
66	635.93
67	635.95


TOWN OF VEGREVILLE
COUNTY OF MINBURN
47 STREET
VERMILION
RIVER
HIGHWAY
WATER SUPPLY RESERVOIRS
7-52-14
W. OF 4


CANADA
AGRICULTURE
MINBURN
RIVER
HIGHWAY 16 BYPASS
8-52-14
W. OF 4

33	633.19
34	633.38
35	633.48
103	633.60
37	633.64
38	633.77
104	633.80
40	633.80
41	633.92
42	634.05
105	634.10
44	634.11
45	634.11
46	634.19
47	634.42

55	634.96
68	634.96
69	634.96
56	634.97
57	635.00
58	635.09
59	635.27
60	635.35
61	635.35
62	635.35
63	635.37
64	635.77
65	635.86
66	635.93
67	635.95

E -70000

E -69500

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DAMAGE
REDUCTION
PROGRAM

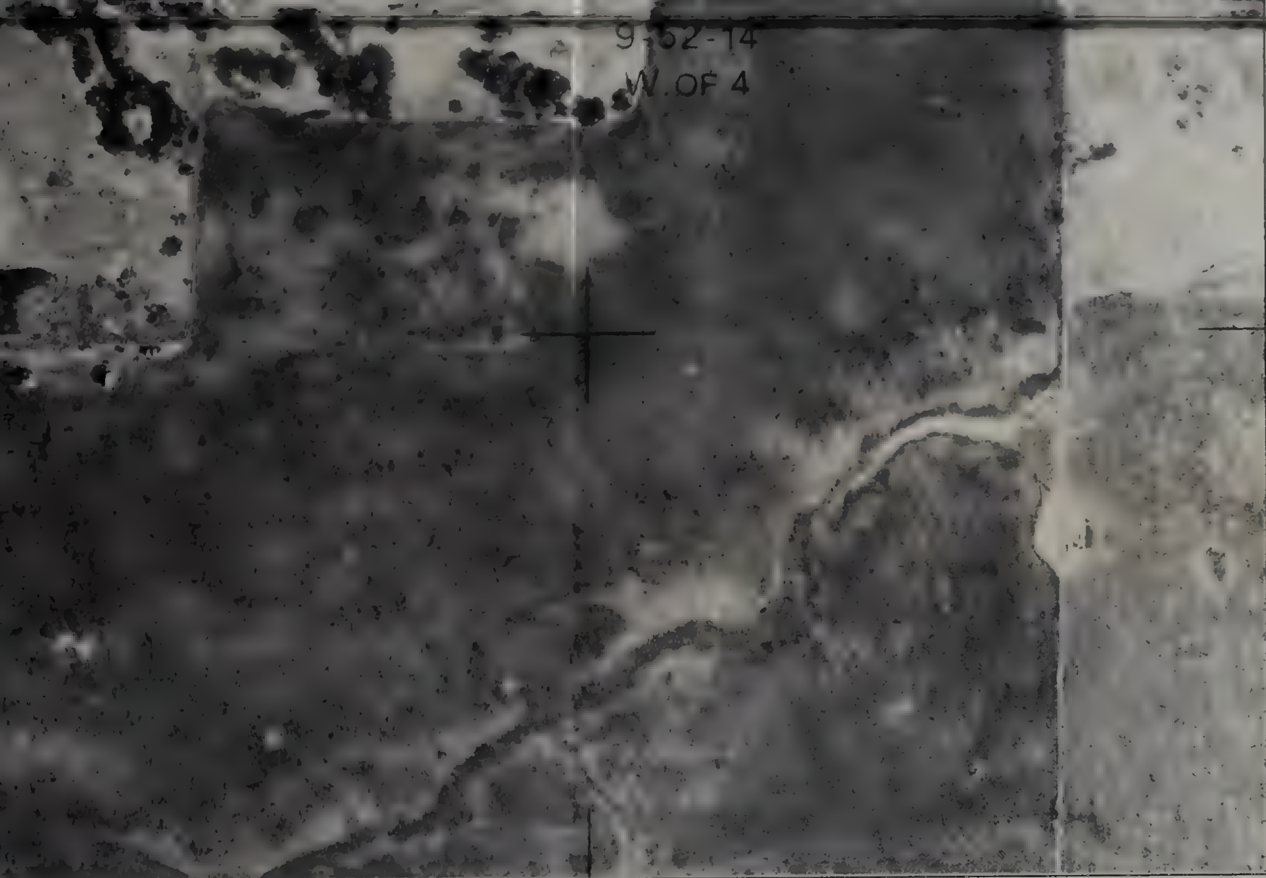
Environment Canada
Environnement Canada

Alberta
ENVIRONMENTAL PROTECTION

February 1993 SNCSTDTB

A0 1189 x 841


W OF 4
E -69000
E -68500
E -68000
E -67500



SCALE 1 : 5 000

Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: in metres above mean sea level, North American Datum, 1927

1.0 metre contour

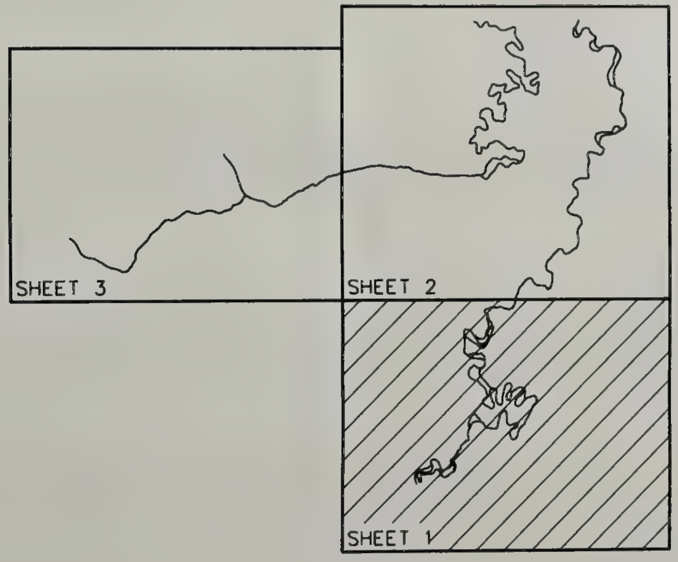
1.0 metre index contour

Depression contour

.1882.6 Spot height in metres

Orthophoto MAY 1991

Contours MAY 1991



SHEET INDEX

SNC·LAVALIN

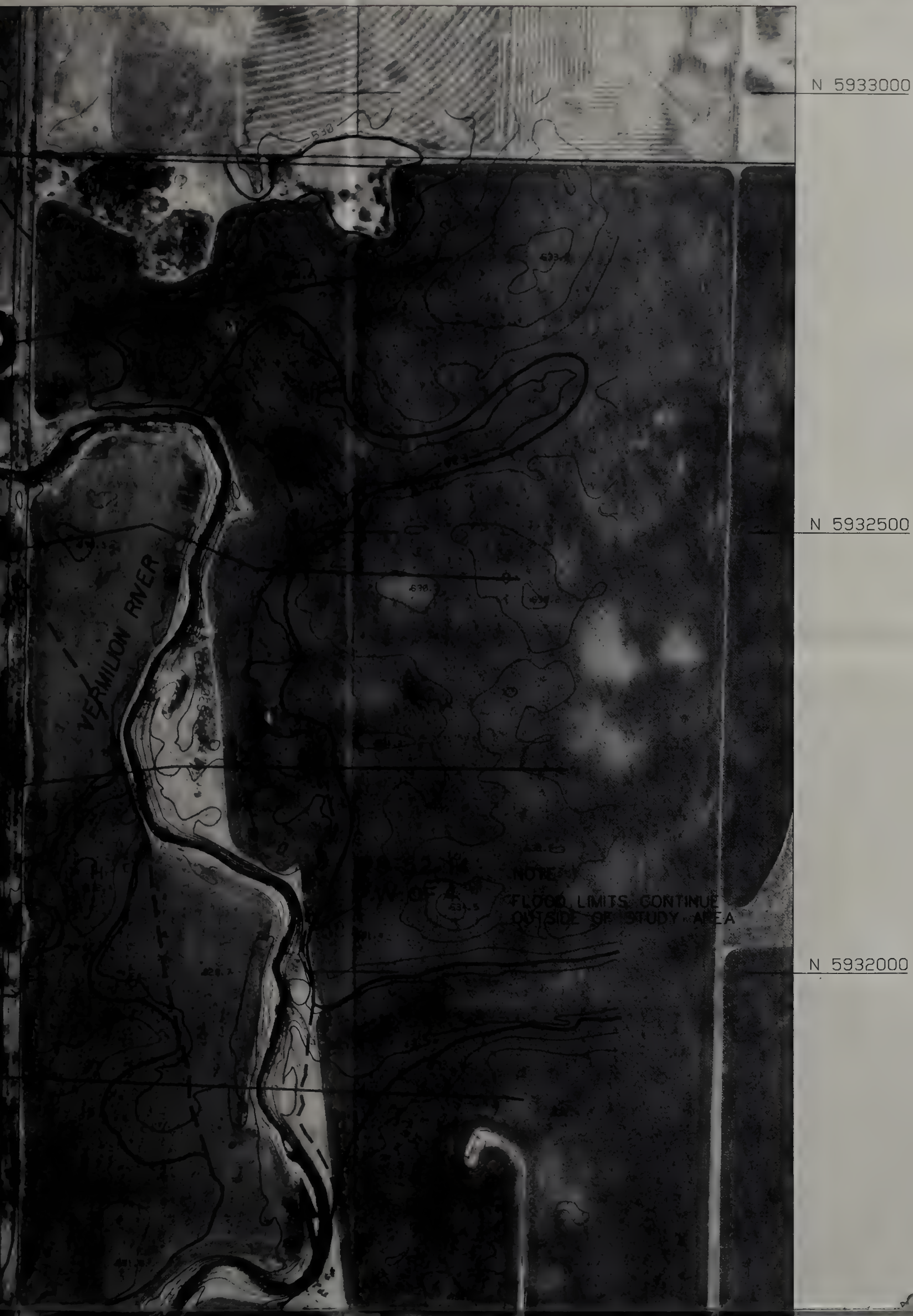
PROJECT: VEGREVILLE FLOOD RISK MAPPING STUDY		
DRAWING TITLE: FLOOD RISK MAP SHEET 1		JOB No
		ACCOUNT No
CLIENT DRAWING No	REV	SCALE 1:5000
DRAWING No 6005-301		REV

Filename : 600500AB.DGN


NOTE:
NORTH DRAIN WEST TRIBUTARY
IS BLOCKED AT 47 STREET;
OVERBANK FLOW OCCURS
AT SECTION 99 AS SHOWN
NOTE:
SPILL OVER ROADWAY MAY OCCUR
INTO DITCHES AND SWALES FOR
1:50 AND HIGHER FLOODS
0-52-14
W. OF 4
41 STREET
GOLF
COURSE
98
99
97
108

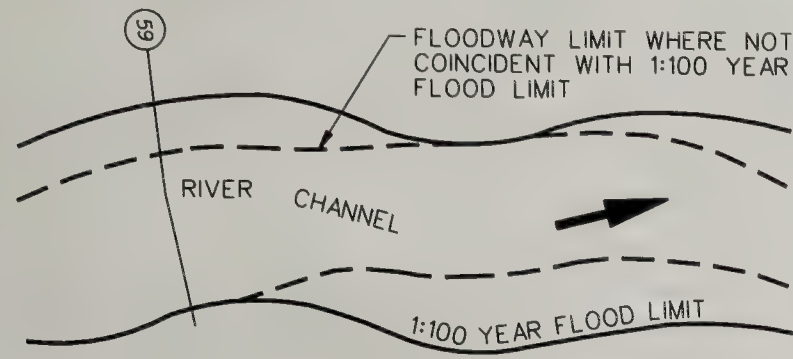
NOTE:
NORTH DRAIN WEST TRIBUTARY
IS BLOCKED AT 47 STREET;
OVERBANK FLOW OCCURS
AT SECTION 99 AS SHOWN
NOTE:
SPILL OVER ROADWAY MAY OCCUR
INTO DITCHES AND SWALES FOR
1:50 AND HIGHER FLOODS
0-52-14
W OF 4
47 STREET
GOLF
COURSE
128
99
97
206

0
5
10
20
25
30
WEST TRIBUTARY
AT 47 STREET
LOW OCCURS
99 AS SHOWN
NOTE:
SPILL OVER ROADWAY MAY OCCUR
INTO DITCHES AND SWALES FOR
:50 AND HIGHER FLOODS
47 STREET
GOLF
COURSE
VERMILION RIVER



N

LEGEND



59 — CROSS-SECTION NUMBER AND LOCATION (ORIENTED FACING DOWNSTREAM)

TOWN BOUNDARY

FLOW DIRECTION

H — HIGHER GROUND ABOVE FLOOD LIMITS

NOTE - VEGREVILLE AIRPORT AREA FLOODING

IN THE VEGREVILLE AIRPORT AREA OVERBANK FLOODING FROM THE NORTH DRAIN WEST TRIBUTARY (NDWT), WILL TEND TO BE AT A HIGHER ELEVATION THAN OVERBANK FLOODING FROM THE VERMILION RIVER. THIS WILL TEND TO CAUSE FLOOD WATERS TO FLOW FROM THE NDWT TO THE VERMILION RIVER. IN THAT SITUATION THE VERMILION RIVER LEFT OVERBANK FLOOD LIMITS WILL BE SUPERSEDED BY THE FLOW COMING FROM THE NDWT. NEVERTHELESS THE VERMILION RIVER LEFT OVERBANK FLOOD LIMITS HAVE BEEN RETAINED ON THIS MAP, BUT AS LIGHTER LINES.

WATER SURFACE ELEVATION IN METRES, FOR 1:100 YEAR FLOOD WITH FLOODWAY ENCROACHMENTS

VERMILION RIVER

CROSS-SECTION NUMBER	ELEVATION
1	629.80
2	629.97
3	630.24
4	630.44
5	630.71
6	630.94
101	631.10
8	631.11
9	631.25
10	631.37
11	631.46
12	631.58
13	631.62

CROSS-SECTION NUMBER	ELEVATION
14	631.62
15	631.62
16	631.70
17	631.78
18	631.80
102	631.85
20	631.85
21	631.95
22	632.08
23	632.23
24	632.37
25	635.48

COUNTY OF MINBURN
OLD
AIRPORT ROAD
TOWN OF VEGREVILLE
NORTH
DRAIN
WEST
TRIBUTARY
50 STREET
52-14
W. OF 4

EGREVILLE
AIRPORT
OLD AIRPORT ROAD
OLD
RPORT ROAD
61 AVENUE
RIVER
21-52-14
W. OF 4
SEWAGE LAGOONS

WATER SURFACE ELEVATION IN METRES, FOR 1:100 YEAR FLOOD WITH FLOODWAY ENCROACHMENTS

VERMILION RIVER

CROSS-SECTION NUMBER	ELEVATION
1	629.80
2	629.97
3	630.24
4	630.44
5	630.71
6	630.94
101	631.10
8	631.11
9	631.25
10	631.37
11	631.46
12	631.58
13	631.62

CROSS-SECTION NUMBER	ELEVATION
14	631.62
15	631.62
16	631.70
17	631.78
18	631.80
102	631.85
20	631.85
21	631.95
22	632.08
23	632.23
24	632.37
25	635.48

NORTH DRAIN WEST–TRIBUTARY

CROSS-SECTION NUMBER	ELEVATION
128	629.90
99	629.90
97	630.03
2	630.04
3	630.07
4	630.11
5	630.17
6	630.32
101	630.47
8	630.82
102	630.82
103	630.83
10	630.85
11	630.87
104	630.89
13	631.08
105	631.09
106	631.09
15	631.09
107	631.10
108	631.33
17	631.61
109	631.61
110	631.61
19	631.61
111	631.61
111	631.61
112	631.62
96	631.62
113	631.62
114	631.62

CROSS-SECTION NUMBER	ELEVATION
23	631.62
115	631.62
116	631.63
25	631.63
117	631.63
118	631.64
27	631.64
28	631.64
127	631.65
29	631.66
30	631.66
31	631.66
126	631.69
32	631.69
33	631.70
34	631.71
35	631.72
36	631.75
119	631.78
38	632.34
39	632.34
40	632.34
41	632.34
120	632.34
43	633.41
44	633.41
45	633.41
46	633.41
47	633.41
48	633.41

SCALE 1 : 5 000

metres 0 100 200 300 400 500 600 metres

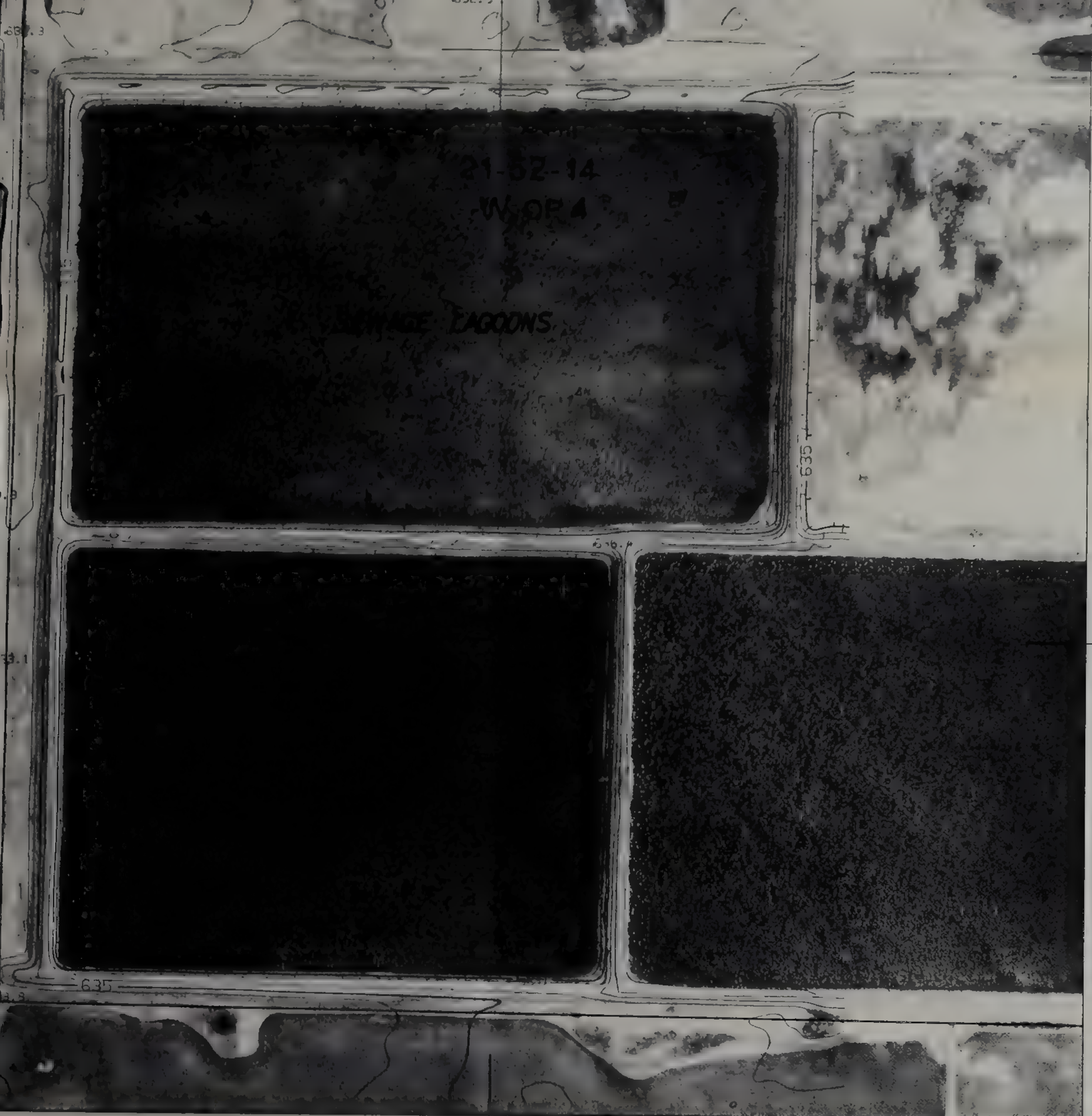
Canada-Alberta FLOOD DAMAGE REDUCTION PROGRAM

Environment Canada / Environnement Canada

Alberta
ENVIRONMENTAL PROTECTION

February 1993 SNCSTDTB
A0 1189 x 841


52-14
W. OF 4
21-52-14
W. OF 4
SEWAGE LAGOONS
RIVER
VERMILION
CEMETERY
47 STREET
E -69000
E -68500
E -68000
E -67500
E -67000



N 5930500

N 5930000

E -67000

SCALE 1 : 5 000

metres 0 100 200 300 400 500 600 metres

feet 0 100 500 1,000 1,500 2,000 feet

Projection: 3° Transverse Mercator. Scale factor 0.9999 at Reference Meridian 111°

Contour Interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: In metres above mean sea level, North American Datum, 1927

1.0 metre contour

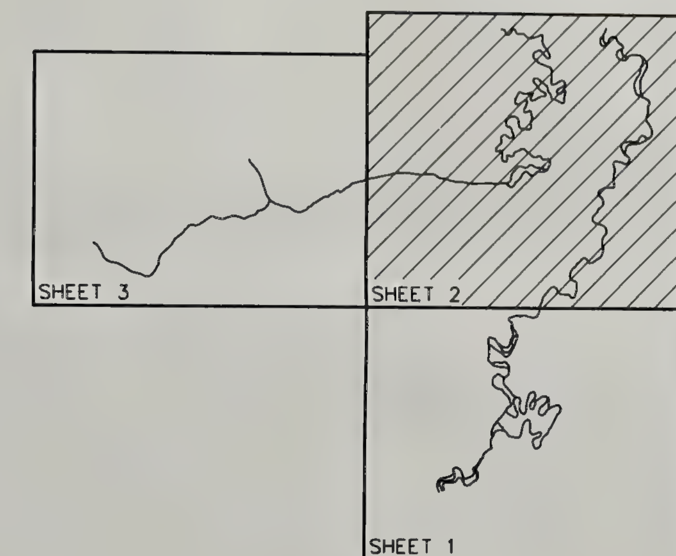
1.0 metre index contour

Depression contour

.1002.6 Spot height in metres

Orthophoto MAY 1991

Contours MAY 1991



SHEET INDEX

PROJECT:
VEGREVILLE FLOOD RISK MAPPING STUDY

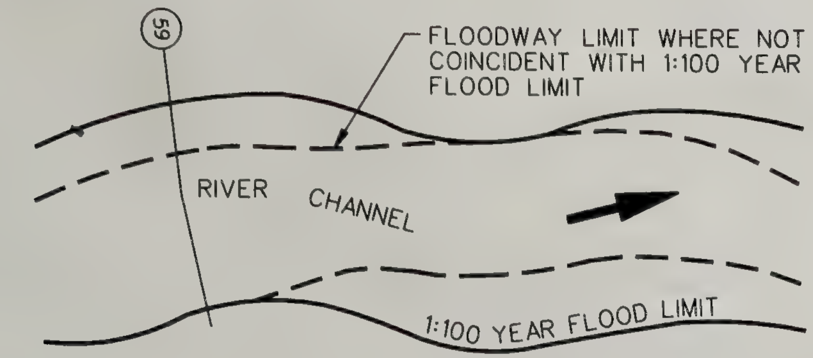
SNC·LAVALIN	DRAWING TITLE FLOOD RISK MAP SHEET 2	JOB No ACCOUNT No
	CLIENT DRAWING No REV	SCALE 1:5000
	DRAWING No 6005-302	REV

Filename : 600500AC.DGN


27-52-15
W.OF 4
26-52-15
W.OF 4
C.N.R.
COUNTY OF MINBURN

52-15
OF 4

LEGEND



(59) CROSS-SECTION NUMBER AND LOCATION (ORIENTED FACING DOWNSTREAM)

TOWN BOUNDARY

FLOW DIRECTION

H HIGHER GROUND ABOVE FLOOD LIMITS

WATER SURFACE ELEVATION IN METRES, FOR 1:100 YEAR FLOOD WITH FLOODWAY ENCROACHMENTS

CROSS-SECTION NUMBER	ELEVATION
48	633.41
121	633.48
50	634.37
51	634.46
52	634.46
53	634.48
54	634.50
55	634.53
56	634.69
61	634.80
122	634.88
63	634.99
123	634.99
124	635.00
65	635.21
66	635.33
67	635.40
68	N.A.
125	635.51
69	635.68
70	635.80

CROSS-SECTION NUMBER	ELEVATION
76	636.47
77	
78	636.75
79	636.77
80	636.77
81	636.84
82	636.91
83	637.00
84	637.00
85	637.21
86	637.49
87	637.68
88	638.06
89	638.66

SWALE A

CROSS-SECTION NUMBER	ELEVATION

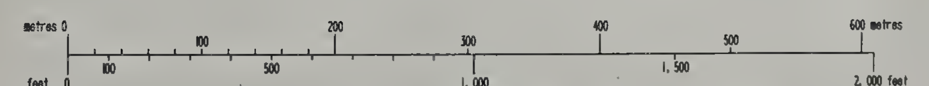
COUNTY OF MINBURN
TOWN OF VEGREVILLE
22-52-15
W.OF 4
23-52-15
W.OF 4
HIGHWAY 16 BYPASS

SWALE 'A'
NORTH DRAIN WEST TRIBUTARY
24-52-23-W4
ALBERTA ENVIRONMENTAL CENTRE
75 STREET
C.N.R.
HIGHWAY 16

125	635.51
69	635.68
70	635.80
71	635.84
72	636.10
73	N.A.
74	636.35
75	636.37

CROSS-SECTION NUMBER	ELEVATION
56	634.69
57	634.69
58	634.69
59	634.69
60	634.90

SCALE 1 : 5 000



Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: in metres above mean sea level, North American Datum, 1927

1.0 metre contour

Depression contour

1.0 metre index contour

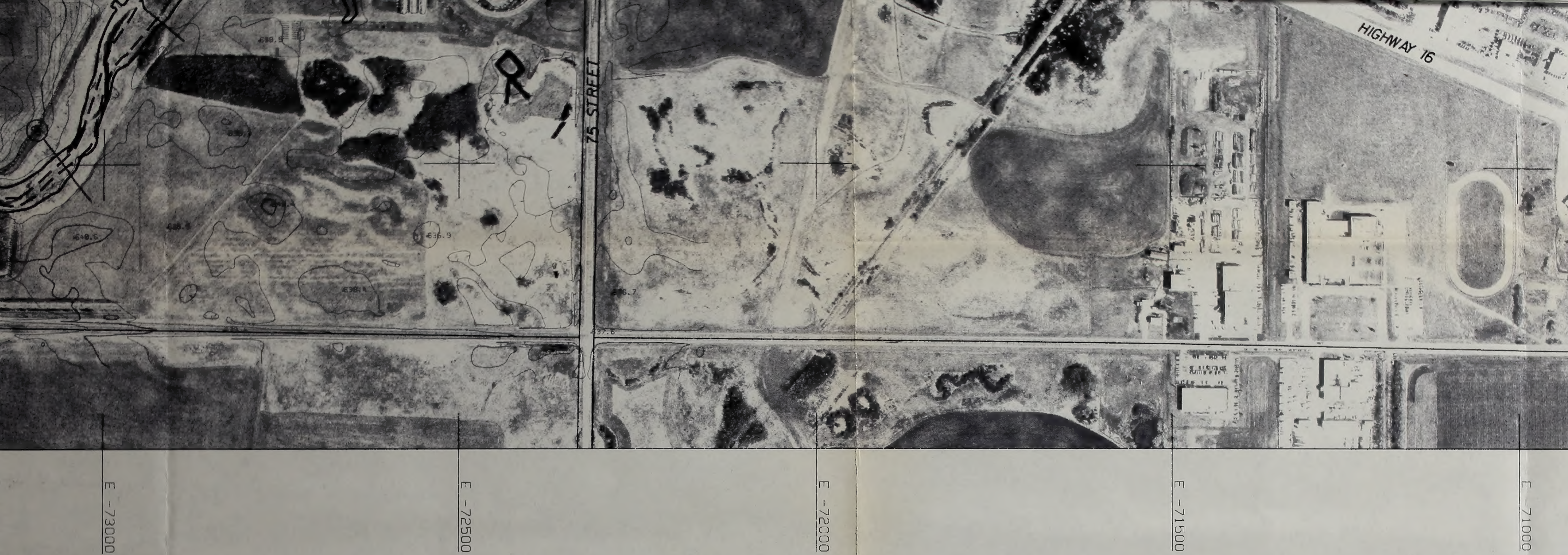
.1882.6 Spot height in metres

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Environment Canada
Environnement Canada

Alberta
ENVIRONMENTAL PROTECTION

February 1993 SNCSTDTB
A0 1189 x 841


HIGHWAY 16
75 STREET
E -73000
E -72500
E -72000
E -71500
E -71000

SCALE 1 : 5 000

metres 0 100 200 300 400 500 600 metres
feet 0 100 500 1,000 1,500 2,000 feet

Projection: 3° Transverse Mercator, Scale factor 0.9999 at Reference Meridian 111°

Contour Interval: 1.0 METRE Where the ground is fully obscured, contours are dashed.

Where the index contours are less than 5mm apart, intermediate contours have been dropped.

Elevations: In metres above mean sea level, North American Datum, 1927

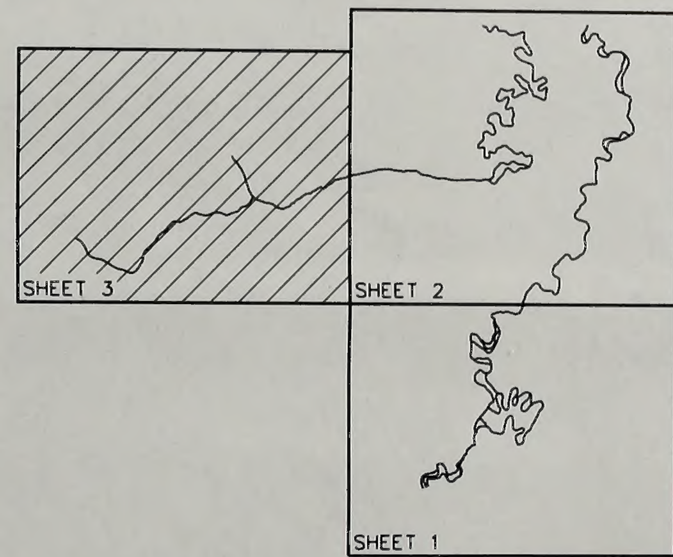
1.0 metre contour

1.0 metre index contour

Depression contour

.1082.6 Spot height in metres

Orthophoto MAY 1991
Contours MAY 1991



SHEET INDEX

SNC·LAVALIN

PROJECT: VEGREVILLE FLOOD RISK MAPPING STUDY		
DRAWING TITLE FLOOD RISK MAP SHEET 3		JOB No
		ACCOUNT No
CLIENT DRAWING No	REV	SCALE 1:5000
DRAWING No 6005-303		REV

Filename : 600500AD.DGN